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NAVAL ARCHITECTURE.

By CHAS. H. HASWELL, C. and M. E.

No. 1.

RESULTS OF EXPERIMENTS UPON THE FORM OF VESSELS.

[Wm. Bland.]

Cubical Models.

Head Resistance.—Increases directly with the area of its surface.

Resistance to Weight.—Increases directly as the weight.

Vessel's Models.

Lateral Resistance.—About one twelfth of the length of the body immersed, varying with the speed.

Order of Superiority of Amidship Section.

Rectangle, Semi-circular, Ellipse and Triangle.

The centre of lateral resistance moved forward as the model progressed.

The centre of gravity had no influence upon the centre of lateral resistance.

RELATIVE SPEEDS.

Length.—Increased length gave increased speed or less resistance.

Depth of Flotation.—Less depth a vessel can be borne upon water, less the resistance.

Amidship Section.—Curved sections gave higher speed than angled.

Sides.—Slight horizontal curves present less resistance than right lines.

Curved sides with one-fourth more beam gave equal speeds with straight sides of less beam.

Keels.—Length of keel has greater effect than depth.

Stern.—Parallel-sided after body gave greater speed than a taper-sided.

Form of Bow.	Order of Speed.
Isosceles triangle, sides slightly convex,	1
" " " right lines,	2
" " " slightly concave at entrance and running out convex,	3

Spherical equilateral triangle compared to *Equilateral triangle*, speed was as 11 to 12. *Equilateral triangle*, with its isosceles sides, was as 5 to 4.

When bow had an angle of 14° with plane of heel, compared with one of 7° its speed was greater.

Bodies Inclined Upward from Amidship Section.

1. Model with bow inclined from "dead flat," had less resistance than model without any inclination.

2. Model with stern inclined from "dead flat," had less resistance than model without any inclination.

Model 1 had less resistance than model 2. Model with both bow and stern inclined from "dead flat," had less resistance than either 1 or 2.

By experiments of Mr. Froude, resultant speed at different velocities, in case of two large vessels, was as follows:

4 knots,	·6 1·
6 "	1·4 2·3
8 "	2·5 3·9
10 "	4·7 6·
12 "	9· 9·

STABILITY.

With equal lengths, ratio of stability is at its limit of rapid increase when width is one-third of length, being nearly in cubic ratio, afterwards it approaches to arithmetic ratio.

RESULTS OF EXPERIMENTS UPON THE STABILITY OF RECTANGULAR BLOCKS OF WOOD OF UNIFORM LENGTH AND DEPTH, BUT OF DIFFERENT BREADTHS.—[W. Bland.]

(Length 15, Depth 2, and Depression 1 inch.)

Width.	Weight.	Ratio of Stability.			
		As Observed.	With like Weights.	By Squares of the Widths.	By Cubes of the Width.
Ins.	Oz.				
3·	24	1·	1·	1·	1·
4·5	35	2·5	2·4	2·25	3·375
6·	45	7·	3·7	4·	8.
7·	55	11·	4·8	6·25	15·625

Hence it appears, that rectangular and homogeneous bodies of a uniform length, depth, weight and immersion in a fluid, but of different widths, have stability for uniform depressions at their sides (heeling) nearly *as the squares of their width*; and that, when the weights are directly as their widths, their stability under like circumstances is nearly *as the cubes of their width.*

RESULTS OF EXPERIMENTS UPON THE STABILITY AND SPEED OF MODELS HAVING AMIDSHIP SECTIONS OF DIFFERENT FORMS, BUT OF UNIFORM LENGTH, WIDTH AND WEIGHTS.—[W. Bland.]

(Immersion different, depending upon form of Section.)

Form of Immersed Section.	Stability.	Speed.
Half-depth triangle; the other half rectangle,	12·	4·
Rectangle, ...	14·	3·
Right-angled triangle,* . .	7·	3·
Semicircle, ...	9·	2·

* Draught of water or immersion double that of the rectangle.

BOTTOM AND IMMERSED SURFACE OF HULL OF VESSELS.

To Compute the External or Bottom and Side Surface of the Hull of a Vessel.

Bottom and Side. Rule.—Multiply the length of the curve of the amidship section, taken from the top of the tonnage or main deck beams upon one side to the same point upon the other (omitting the width of the keel), by the mean of the lengths of the keel and between the perpendiculars in feet, and multiply the product by ·85 or ·9 (according to the capacity of the vessel), and the product will give the surface required in square feet.

Example.—The lengths of a steamer are as follows: Length of keel 201 feet, and between the perpendiculars 210 feet; length of the curved surface of the amidship section 76 feet. What is the surface? Coefficient assumed ·87.

$\overline{210+201} \div 2 = 205{\cdot}5$, and $76 \times 205{\cdot}5 \times {\cdot}87 = 13{,}587$ square feet.

Note.—The exact surface as measured was 13,650 square feet.

Bottom Surface.—Rule.—Multiply the length of hull at the load line by its breadth, and this product by the depth of the immersion, (omitting the depth of the keel) in feet; and this product multiplied by from ·07 to ·08 (according to the capacity of the vessel) will give the surface required in square feet.

Example.—The length upon the load line of a vessel is 310 feet, the beam 40 feet, the depth of the keel 1 foot, and the draught of water 20 feet; what is the bottom or wet surface?

Coefficient assumed ·073.

$310 \times 40 \times \overline{20-1} \times {\cdot}073 = 17{,}199$ square feet.

To compute power required in a steam vessel, capacity of another vessel being given.

In vessels of similar models,

$$\frac{v\,A}{a} = V;\quad \frac{S^3 V}{s^3} = V';\quad \frac{r'\,v'}{r} = C \text{ and } \frac{C}{2r} = R.$$

v representing product of volume of given cylinder and revolutions in cube feet, a and A, areas of immersed section of given and required vessel at like revolutions and speed of given vessel in cube feet, s and S, speeds of given and required vessel at revolutions of given vessel in cube feet, r and r′, revolutions of given and required vessel, and C, product of volume of combined cylinder and revolutions for required vessel.

ILLUSTRATION.—A steam vessel having an area of amidship section of 675 square feet, has two cylinders of a combined capacity of 533·33 cube feet, and a speed of 10·5 knots per hour, with 15 revolutions of her engines. Required volume of steam cylinders, with a stroke of 10 feet, for a section of 700 feet and a speed of 13 knots with 14 revolutions.

$v = 533{\cdot}33 \times 15 = 8000$ cube feet, $\frac{8000 \times 700}{675} = 8296{\cdot}3$ cube feet, $\frac{15^3 \times 8296{\cdot}3}{10{\cdot}5^3} = 15{,}745{\cdot}2$ cube feet, $\frac{15 + 15{,}745{\cdot}2}{14{\cdot}5} = 16{,}288{\cdot}1$ cube ft., and $\frac{16{,}288{\cdot}1}{2 \times 14{\cdot}5} = 566{\cdot}66$ cube feet, which $\div$ 10 stroke of piston, 12 for inches and $\times$ 1728 for inches in a cube foot $= \frac{561{\cdot}66 \times 1728}{10 \times 12} = 8087.9$ square inches area of each cylinder = diameter of 101·5 inches.

APPROXIMATE RULES TO COMPUTE SPEED AND INDICATED HORSE POWER OF STEAM VESSELS.

$$\frac{V^3 D^{\frac{2}{3}}}{IHP} = C; \quad \sqrt[3]{\frac{C\,IHP}{D^{\frac{2}{3}}}} = V; \text{ and } \frac{V^3 D^{\frac{2}{3}}}{C} = IHP$$

$$\text{or } \sqrt[3]{\frac{C\,IHP}{A}} = V; \text{ and } \frac{V^3 A}{C} = IHP.$$

C representing coefficient of vessel, A area of immersed amidship section, V velocity of vessel in knots per hour, and D displacement of vessel in tons.

NOTE.—When there exists rig, an unusual surface in free board deck houses, etc., or any element that effects coefficient for the class of vessel given, a corresponding addition to, or decrease, or addition of the following units is to be made:

Range of Coefficients as deduced from observation is as follows:

SIDE WHEEL.	*A*	*D*	*V*	*C* $\frac{V^3 A}{IHP}$	*C* $\frac{V^3 D^{\frac{2}{3}}}{IHP}$
	Sq. ft.	Tons.	Knots.		
River steamboat medium lines,	43	73	10	470	212
" " " "	150	465	13	570	219
" " fine "	136	300	19	540	200
Sea steamer medium full lines,*	675	3600	10	650	214
" fine lines,†	550	5233	15	650	211

* Full rigged. † Bark rigged.

Screw Propeller.	A	D	V	$\frac{V^3 D^{\frac{2}{3}}}{IHP}$	$\frac{V^3 A}{IHP}$
	Sq. ft.	Tons.	Knots.		
River steamboat medium lines,	45		12	500	
" " fine "	150		15	530	
Torpedo boat " "		27	20	500	170
Sea steamer medium full lines,*	550	2532	9	570	194
" " " " *	390	1475	10	470	180
" fine lines		3660	13		210

Coefficients as Determined by Several Steamers of H. B. M. service.
(C. Mackrow, M. I. N. A.)

Length.	$\frac{\text{Length}}{\text{Beam.}}$	Area of section at 0.	Displacement.	IHP.	Speed.	$\frac{V^3 A}{IHP} =$
Heel.		Sq. ft.	Tons.		Knots.	
185	6·53	236	775	782	10·34	333
212	5·89	377	1554	1070	10·89	456
360	7·33	814	5898	2084	11·5	598
270	6·43	632	3057	2046	12·3	574
380	6·52	1308	9487	3205	12·05	714
400	6·73	1198	9152	5971	13·88	536
362	7·33	778	5600	3945	14·06	548
400	6·73	1185	9071	6867	15·43	634

Proportion of Power Utilized in a Steam Vessel.

side wheel.

$$\frac{P-z}{\cdot 00000259 \times d^3 \times r^2} = C.$$ *P representing gross Indicated Horse-Power, z, loss of effect by slip and oblique action of wheel (or propeller), d, diameter of wheels at centre of effect, r, revolutions per minute, and C, coefficient for the vessel.*

Illustration.—The indicated horse-power of the engines of a side-wheel steamer is 1120; the slip of the wheels and loss by oblique action, 33·37 per cent.; the diameter of the centre of effect of the wheels is 29·5 feet, and the number of revolutions 13·5 per minute; what is the coefficient, and what the power applied to propel the vessel?

Note.—The slip of the wheels from their centre of effect in this case is 15·37 per cent., and the loss by oblique action 18 per cent. Hence,

* Full rigged.

representing the total power by 100, $100 - (18+15{\cdot}37) = 66{\cdot}63$ per cent. of the power applied to the wheels.

As the assumed power that operates upon the wheels in this case is taken at 86·12 per cent. of the power exerted by the engines, $86{\cdot}12 \times 22{\cdot}37 = 28{\cdot}74$ per cent. for the sum of loss by the wheels.

$$\frac{1120-(1120\times 28{\cdot}74\div 100}{{\cdot}00000259\times 29{\cdot}5^3\times 13{\cdot}5^2} = \frac{798{\cdot}11}{12{\cdot}16} = 65{\cdot}53 \text{ coefficient.}$$

The speed of the vessel being 10 knots per hour = 17·05 feet per second, the power applied to propel the vessel at this speed $= 65{\cdot}63 \times 17{\cdot}05^2 = 19{,}076{\cdot}13$, and the horse-power exerted =

$$\frac{19{,}076{\cdot}13\times 17{\cdot}05\times 60}{33{,}000} = 591{\cdot}36 \text{ horses-power.}$$

Side Wheel.

	Horse-power.	Per cent. of power.
Friction of engines 1·5 lbs. upon 3848 sq. ins. × 13·5 revolutions × $\overline{10 \times 2} \div 33{,}000 \times 2$ =	94·45	18·83
Friction of load 6 per cent. upon pressure of steam, less the 2 lbs. for friction of engine, as above =	60·45	
Oblique action of wheels =	201·6	18·
Slip of wheels =	172·14	15·37
Absorbed by propulsion of vessel	591·36	52·8
	1120·	100·

Screw Propeller.

	Horse-power.	Per cent. of power.
Friction of engines =	96·06	18·83
" of load =	81·48	
" of screw surface and resistance of edges of blades =	53·44	6·83
Slip of propeller =	205·55	26·27
Absorbed by propulsion of vessel	375·92	48·04
	782·45	100·

From experiments of Mr. French,* he deduced that, as a rule, that only 37 to 40 per cent. of whole power exerted was usefully employed.

With an auxiliary propeller, essential differences are in friction of surfaces and edges of blades of propeller and slip of propeller, being

* Transactions of Institution of Naval Architects, vol. xvii.

as 12 to 6·83 in excess in first case, and as 13·7 to 26·27 in second case, or 50 per cent. less.

To Compute the Resistance to the Wet Surface of the Hull of a Vessel.

$C\,a\,v^2 = R$. *C representing a coefficient of resistance, a area of wet surface in square feet, and v velocity of hull in feet per second.*

Values of *C*, ·007, clean copper. ·014, iron plate. ·01, smooth paint. ·019, iron plate, moderately foul.

The power required to propel one square foot of immersed amidship section at "dead flat" is ·073 that of smooth wet surface.

Elements of Capacity and Speed of Several Types of Steamers of R. N. (W. H. White.)

Classes.	Length.	Length to Breadth.	Displacement.	Speed.	I. H.-P. to Displacement.	I. H.-P. to Displacement $\frac{2}{3}$
Iron Clads.	Feet.		Tons.	Knots.		
Early types	380 to 400	6·5 to 6·75	9000 to 10500	14· to 14·5	·6 to ·7	11 to 14
Recent "	300 to 330	5·25 to 5·75	7500 to 9000	14· to 15·	·9 to 1·	16 to 20
" " twin screws	280 to 320	4·5 to 5·	6000 to 9000	4· to 15·	·7 to ·9	15 to 19
Unarmored.						
Swift cruisers	270 to 340	6·5 to 6·75	3000 to 5500	15· to 16·	1·3 to 1·5	20 to 24
Corvettes	200 to 220	6	1800 to 2000	12·75 to 13·25	1· to 1·2	13 to 14
Ships	160	5	850 to 950	11	1· to 1·2	10 to 11
Gun vessels	125 to 170	5·5 to 6·25	420 to 800	9·5 to 11·	·8 to 1·4	7 to 11
Gun boats (coast)	80 to 90	3· to 3·25	200 to 250	8· to 9·	·8 to 1·1	5 to 7
Merchant.						
Mail, large	400 to 500	9· to 11·	7000 to 10000	14· to 15·	·5 to ·6	10 to 11
" smaller	300 to 400	8· to 10·	5000 to 7000	13· to 14·	·4 to ·5	7 to 10
Cargo, large	250 to 350	7·5 to 10·	3000 to 6000	11· to 15·	·3 to ·5	5 to 9
" smaller	200 to 300	7· to 9·	1500 to 4000	9· to 11·	2 to 2·4	3 to 6

TO COMPUTE ELEMENTS OF A VESSEL.

DISPLACEMENT AND ITS CENTRE OF GRAVITY.

Displacement of a vessel is volume of her body below water-line, or line of immersion.

Centre of Gravity, or Centre of Buoyancy of Displacement, is centre of gravity of water displaced by hull of vessel.

For Displacement. RULE.—Divide vessel, on half breadth plan, into a number of equidistant sections, as one, two or more frames, commencing at "dead flat" and running each side of it. Add together lengths of these lines in both fore and aft bodies, except first and last, by by Simpson's rule for areas; multiply sum of products by one-third distance between sections, and product will give area of water-line between fore and aft sections.

Then compute areas contained in sections forward and aft of sections taken, including stern and rudder post, rudder and stem, and add sum to area of body sections already ascertained.

Compute area of remaining water-lines in like manner.

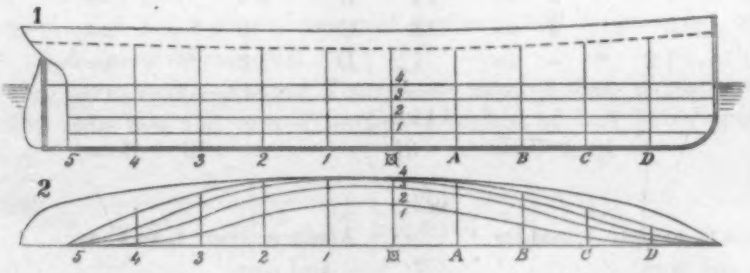
Tabulate results, and multiply them by Simpson's rule in like manner as for a water-line, and again by consecutive number of water-lines, and sum of products between water-line, and product will give volume between load and lower water-line.

Add area of lower water-line to area of upper surface of keel; multiply half sum by distance between them, and product will give volume. Compute areas contained in sections forward and aft of sections taken as before directed.

If keel is not parallel to lower water-line, take average of distance between them.

Compute volume of keel, rudder post and rudder below water-line; add to volume already ascertained, multiply product by two, for full breadth, and product will give volume required in cubic feet, all dimensions being taken in feet.

EXAMPLE.—Assume a vessel 100 feet in length by 20 feet in extreme breadth, on load-line of 8 feet 9 inches immersion. Figs. 1 and 2.



Distance between sections, for purpose of simplifying this example, is taken at 10 feet; usually frames are 18 to 30 inches apart, and two or more included in a section. Water-lines 2 feet apart.

1st Water-line.

4	5·	–	=	5·
3	7·7	× 4	=	30·8
2	9·5	" 2	=	19·
1	9·9	" 4	=	39·6
0	10·	" 2	=	20·
A	9·6	" 4	=	38·4
B	7·8	" 2	=	15·6
C	6·8	" 4	=	27·6
D	4·	" –	=	4·
				199·6
		10 ÷ 3	=	3⅓
				605·3
Abaft section 4, rudder and post, . .				25·
Forward section D and stem, . .				20·7
				711·

2d Water-line.

4	2·7	–	=	2·7
3	6·9	× 4	=	27·6
2	8·7	" 2	=	17·4
1	9·5	" 4	=	38·
0	9·6	" 2	=	19·2
A	4·	" 4	=	36·
B	7·	" 2	=	14·
C	5·	" 4	=	20·
D	2·	" –	=	2·
				176·9
		10 ÷ 3	=	3⅓
				589·7
Abaft section 4, rudder and post, . .				13·2
Forward section D and stem, . .				9·1
				612·

3d Water-line.

4	1·5	–	=	1·5
3	5·	× 4	=	20·
2	6·6	" 2	=	13·2
1	8·7	" 4	=	34·8
0	8·9	" 2	=	17·8
A	7·6	" 4	=	34·
B	7·	" 2	=	14·
C	3·	" 4	=	12·
D	1·2	" –	=	1·2
				144·9
		10 ÷ 3	=	3⅓
				403·
Abaft section 4, rudder and port, . .				7·
Forward section D and stern, . .				5·4
				495·4

4th Water-line.

4	·7	–	=	·7
3	2·	× 4	=	8·
2	4·3	" 2	=	8·6
1	6·5	" 4	=	26·
0	6·8	" 2	=	13·6
A	5·	" 4	=	20·
B	3·6	" 2	=	7·2
C	·9	" 4	=	3·6
D	·3	" –	=	·3
				88·
		10 ÷ 3	=	3⅓
				293·3
Abaft section 4, rudder and post, . .				3·2
Forward section D and stem, . .				·8
				297·3

Keel.

Half breadth = ·25 × length of 98 feet =	24·5
Rudder post and rudder,	·3
	24·8

RESULTS.

1st water-line,	711·		–	=	711·					
2d "	612·	×	4	=	2448·	×	1	=	2448·
3d "	495·4	"	2	=	990·8	"	2	=	1981·6
4th "	297·3	"	4	=	1189·2	"	3	=	3567·6
Keel,	24·8		–		24·8	"	4	=	99·2
					5363·8				8096·4
					2				
					3)10727·6				

Displacement, 3575·9×2=7151·8 cube feet.

FOR CENTRE OF GRAVITY.

RULE.—Divide sum of products obtained as above by consecutive water-lines, by sum of products obtained in column of products by Simpson's multipliers, and quotient multiplied by distance between water-lines will give depth of centre below load water-line.

ILLUSTRATION.—8096·4, from above, ÷ 5363·8 = 1·5, which × 2 = 3 feet.

Or $\frac{n}{2\left(2 - \frac{D}{an}\right)} = d$. *n representing draught of water exclusive of any drag of keel, a area of immersed surface of hull in square feet, and D displacement in cube feet.*

ILLUSTRATION.—Assume draught of water 8 feet, displacement 7152 cube feet, and area of immersed surface of hull 1100 square feet.

Then $\frac{8}{2\left(2 - \frac{7152}{1100\times 8}\right)} = \frac{8}{2\times 1{\cdot}107} = 3{\cdot}37$ feet.

SAWS.

By Robert Grimshaw, Ph.D.

Continued from page 175.

The Circular Saw.—During all the centuries which witnessed the birth and rise, the haughty supremacy and the fall of nations in successive turns, no important change was made for the better in the manufacture of saws, until, in 1790, a device was brought out by Brunel, by which cutting should be continuous. In other words, the application of the rotary principle to power-driven saws was given practically to the world.* While the circular saw was first practically used in Holland, its development is due to England and America—especially the latter.

The circular or "buzz" saw, not having inertia to overcome in revolving, has a higher cutting speed of teeth than the reciprocating, besides this advantage of continuous cutting.

It is made with solid and with removable teeth. We shall consider the solid-toothed variety first.

Fig. 40. Eight-toothed Weatherboard Saw.

(From Holzapffel, 1846.)

It consists, in its application to wood cutting, of a circular disk of steel, rolled to even gauge, and then generally ground thinner either in the centre or at the rim, after the teeth are cut.

As a general thing, the teeth of circular saws are more distant, more inclined, and more set, than those of rectilinear. But their action may be referred to the tangent of the circle at each tooth, just as in straight saws to the line of the blade.

*The circular saw appears in a British patent of Miller, No. 1152 of 1771. The full text may be found in Richards' work on Wood Working Machines, page 6.

The teeth are more distant, because their great velocity makes their effect almost continuous. In one variety used for cutting feather-edged or weather boards and taking a very deep, wide cut, this is carried to an extreme—there being but eight sectional teeth (see Fig. 40). Fewness of teeth gives the necessary increased throat room for sawdust.

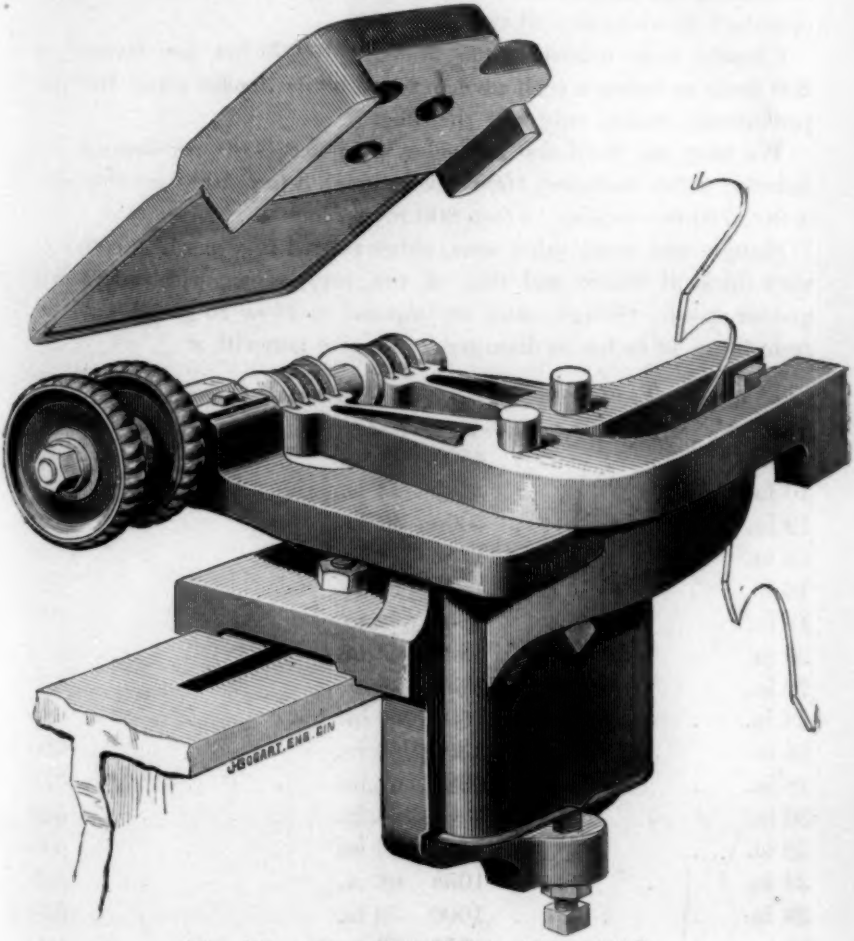


Fig. 41. Lane & Bodley's Side Guide.

Their teeth are more inclined because they have additional power by reason of their great velocity, and hence can stand the extra front rake.

They are more set to make a wider kerf, required by reason of the waving and wabbling at high speeds of the disk, which cannot, of course, even if perfectly homogeneous and true, and unaltered by heat, be kept as rigid as a strained straight blade.*

The circular saw is easily run, and at a high speed. But it requires continuous attendance, the work being so rapidly done as to be in the operator's hands nearly all the time.

Circular saws ordinarily run 9000 to 10,000 feet per minute, or 200 times as fast as a push cut hand saw, which makes about 100 feet per minute, cutting only half the time.

We may say for disks 12 inches diameter, 3000 revolutions per minute; 2 feet diameter, 1500 revolutions; 3 feet, 1000 revolutions; 4 feet, 750 revolutions; 5 feet, 600 revolutions.

Shingle and some other saws, either riveted to a cast iron collar or very thick at centre and thin at rim, may be run with safety at a greater speed. Shingle saws are tapered to 14 or 15 gauge, and run from 30 to 48 inches in diameter. We give herewith a

TABLE OF SPEED FOR CIRCULAR SAWS.

Size of Saw.	Rev. per min.	Size of Saw.	Rev. per min.
8 in.	4500	42 in.	870
10 in.	3600	44 in.	840
12 in.	3000	46 in.	800
14 in.	2585	48 in.	750
16 in.	2222	50 in.	725
18 in.	2000	52 in.	700
20 in.	1800	54 in.	675
22 in.	1636	56 in.	650
24 in.	1500	58 in.	625
26 in.	1384	60 in.	600
28 in.	1285	62 in.	575
30 in.	1200	64 in.	550
32 in.	1125	66 in.	545
34 in.	1058	68 in.	529
36 in.	1000	70 in.	514
38 in.	950	72 in.	500
40 in.	900		

*Something partly answering the purpose of straining is gained by the "side guides" of large circular saws. See Fig. 41.

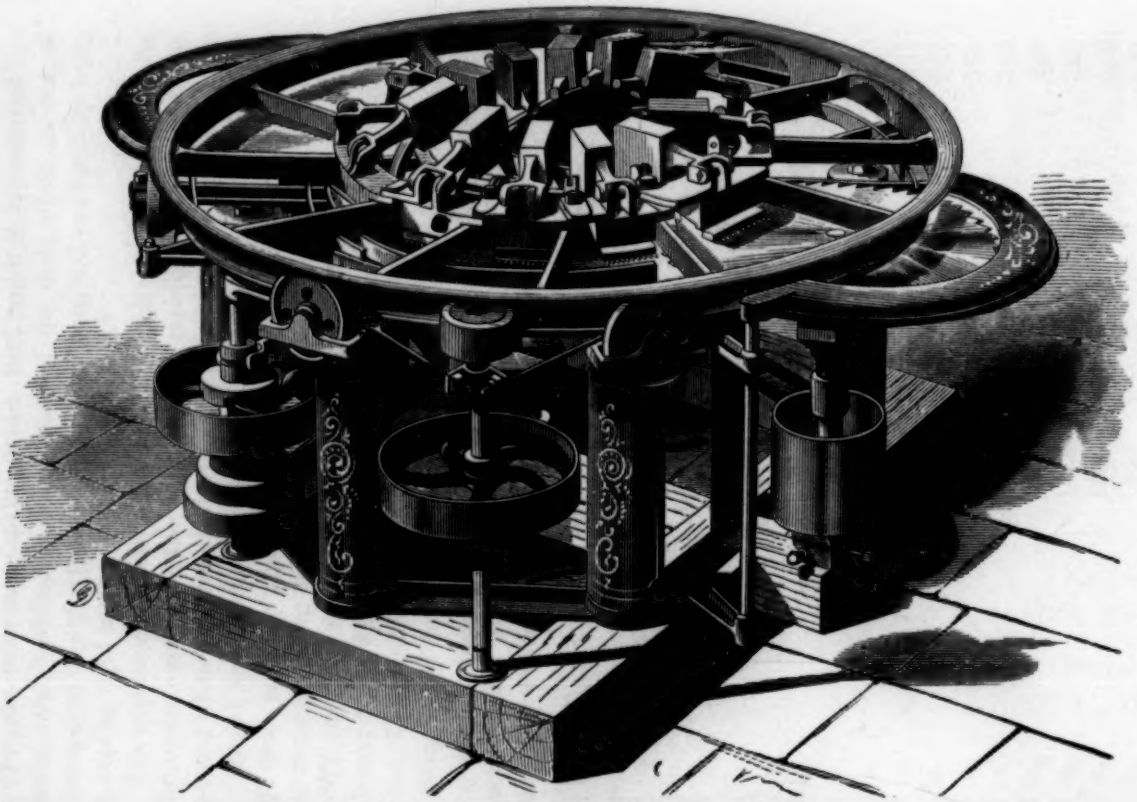


Fig. 42. Largest Shingle Machine in the World.

Richards, in his "Operator's Handbook," gives the following speeds for circulars:

Diam.	R. P. M.	Peripheral Velocity. Feet per min.
36 inches,	1500	14,100
30 "	1800	14,100
25 "	2100	13,700
20 "	2400	12,500
15 "	2700	10,600
10 "	3000	7,000

For shingle making the circular saw is sometimes run horizontally, as illustrated in Fig. 42, which shows the largest shingle machine in the world.

A shingle saw should be re-ground as soon as it wears down to 14 gauge, as the thinner the saw used the more profit. It does not pay to cut timber into sawdust instead of shingles.

Simonds' 36-inch shingle saws (said to be not hammered) make from 1925 turns per minute, and 116 clips, up to 2200 revolutions.

The circular saw should not be used on work thicker than one-third the saw diameter. A 20-inch square "cant" or log would necessitate a 60-inch circular saw, which may be $\frac{7}{32}$ inch thick and make a kerf of $\frac{9}{32}$ inch. But some economy of kerf and hence of time, power and material is gained by the "double circular" mill, having two smaller circulars rotating in the same direction, one cutting from the top, the other from the bottom of the log, in the same plane—one slightly in advance of the other (see Figs. 43 and 44).

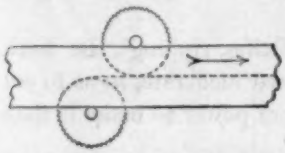


Fig. 43. "Double" Circular Saws.

Thus the 20-inch log cited above could be worked by two 30-inch circulars $\frac{9}{64}$ inch thick, and cutting only $\frac{13}{64}$ inch kerf. In general, the top saw is smaller than the bottom one, the lower one, after successive reductions of diameter by sharpening, being moved to the top mandrel.

In California, redwood logs ten feet in diameter are sawed with three 62-inch vertical circulars, one above the other, in connection with a small horizontal circular which divides the board in the line of

the arbor of the middle saw. The two lower ones cut 58 inches between them, and the upper one takes 29 inches.

In the choice of velocity and teeth of circular saws, there must be taken into consideration the hardness and grain of the material to be cut; its greater or less freedom from moisture, from gummy or resinous matters, and from spikes; also its size and the degree of smoothness required in the surfaces left. The harder the wood the smaller and more upright should be the teeth, and the less their velocity and the rate of sawing.

Fig. 45 shows the circular saw solid tooth for soft wood; Fig. 46 that for hard wood.

Fig. 45. For Soft Wood.

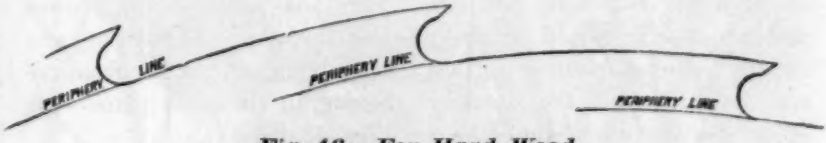


Fig. 46. For Hard Wood.

In cutting lengthwise with the fibres (slitting, ripping), the teeth should be coarse and inclined, and the speed moderate, so as to cut rather than abrade; as fine sawdust takes more power to make it than coarse.

Cutting across grain (cross-cutting, crossing) requires finer and more upright teeth and greater velocity than in the last case, so that each fibre may be rather *cut* by successive teeth than *torn* by only one.

The teeth should be as hooking as they will bear, exeept for lath saws, where the stuff is fed by the saw under the arbor, and for side cutting shingle saws, where this would cause too fast speed.

The more inclined a circular saw tooth is the easier it cuts. With less rake, however, the cut is smoother.

Fig. 44. Double Circular Saw Mill.

The teeth of the "circular" meet the fibres at varying angles. The fibres at the top of the "cant" are met at a very acute angle; those at the bottom at almost a right angle. (Fig. 47.) It follows that the first are cut to the best advantage, and that narrow cuts—that is, those of medium height of cut—are sawed less economically than thick ones, the position of the table being the same.

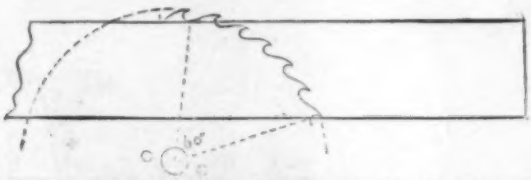


Fig. 47. Action of Top and Bottom Teeth of Circular Saws Compared.

Theoretically speaking, to effect the greatest economy in cutting, the table or carriage should be kept high up, so that the cant should be as nearly as possible tangential to the disk.

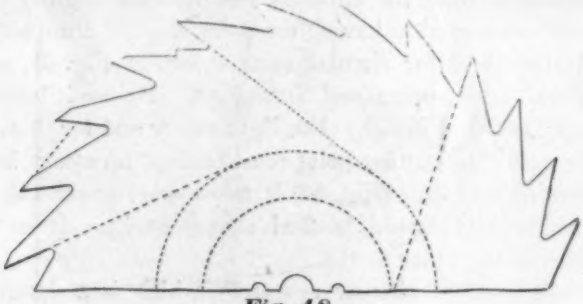


Fig. 48.

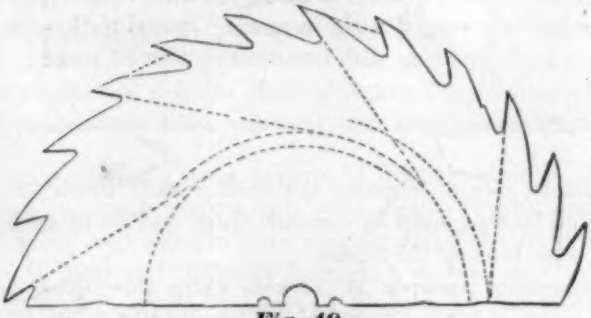


Fig. 49.

Figs. 48, 49 and 50 show teeth made to various tangents.

For pine, spruce and hemlock the teeth should be cut to a tangent to a circle half the saw diameter.

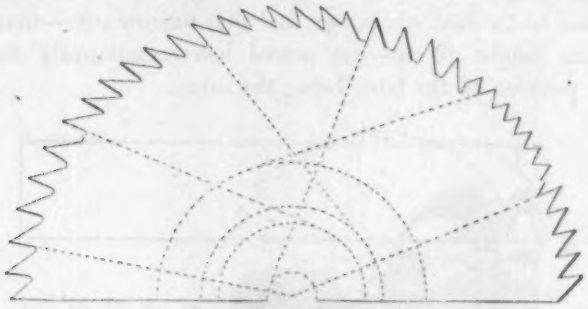


Fig. 50.

The old "Barber" patent tooth had the under side concaved out, and cut very sweetly. The Emerson inserted tooth of the present day has this same feature.

The Knowles tooth for circulars had its back slightly relieved—which really amounted to having the point slightly upturned.

The Gridley tooth for circular saws, shown in Fig. 51, as in order for work, has both spring and spread set. By use it becomes worn and rounded, as in Fig. 52. For light power and tough sawing it is said to do well. Its cutting point must be kept up square and full, as when rounded and dull (Fig. 52) it takes more power and turns out poorer lumber. It should be filed almost exclusively on the under side (as should any other tooth).

An arrangement of circular saw teeth, which is a development of the increment tooth referred to under the head of teeth, has sections of the periphery arranged with increasing spaced teeth—the inventor claiming smoother cutting with less consumption of power. He states that at Cincinnati a 7 gauge, 56-inch, variable spaced circular used from 7 to 20 horse-power less than any other of the same thickness. (See Fig. 53.)

The points *only* of circular saw teeth should touch the lumber. They should be *kept* sharp by constant filing, and set by springing and swaging, so as to clear the blades.

The American tendency is towards extra thin saws, as lumber becomes more and more valuable. They are now made to 54 inches diameter, as thin as No. 12 gauge at rim and 11 at centre; 66 to 72 inches diameter, No. 10 at rim and 9 at centre. In extra thin saws

it is necessary to use a larger number of teeth than in thicker ones. Every $\frac{1}{16}$ inch saved in the width of saw kerf saves 1000 feet of lumber in every 16 M sawed.

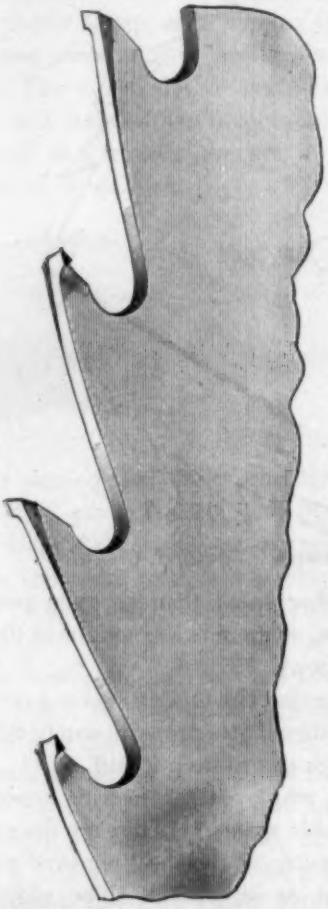


Fig. 51. Gridley Tooth, in good order.

Fig. 52. Gridley Tooth, in bad order.

A circular saw has a great amount of difficult work to do, rapidly. It is something more than a hard steel disk. It must keep its position and work well when in rapid rotation and doing hard duty.

There is little real difficulty in making a "circular" with almost any kind of tooth, that will run well when new; but the steady use and constant changing of the teeth for months are sure to point out all their defects.

Hard circular plates heat easier than soft, and dry lumber causes greater heating than wet.

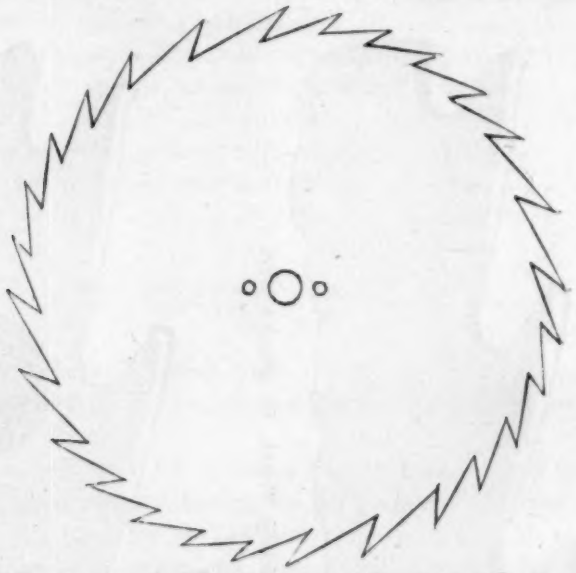


Fig. 53. Andrews' Increment Toothed Circular.

A taper circular will stand a higher speed than an even gauge or one ground thinnest in the centre, as there is less weight at the rim and consequently less centrifugal force.

As a slight offset to the advantage that rim tapering gives a circular, there is this: that as the saw gets smaller it gets proportionately thicker, when it does not need as great a thickness to keep it stiff.

Veneer-cutting circular saws are employed for making veneers or very thin plates, generally of valuable woods.* They are designedly thinner at the edge than in the centre, as the sheet removed readily bends aside. They are either solid or segmented. The edge must run exceedingly true, and the teeth be sharp and very faintly set. The segments are from 5 to 10 gauge, and are 12 inches in diameter.

A segment for large saws is shown in Fig. 54, and a veneer sawing machine in Fig. 55.

* Knife or splitting machines for this purpose answer well enough for straight grained and pliant woods, as Honduras mahogany, but not for irregular, harsh and brittle grain, such as rosewood—as in the last case the veneer curls up considerably on removal, and has a disposition to split and become pervious to glue.

While circular saws for wood can be made up to 80 and 100 inches diameter, there are also smaller "circulars" used for such work as cutting notches in telescopes and in screw heads, slits of bat's-wing gas burners, etc. The teeth of these last are sometimes serrated with a screw cutter or tap, as in making the teeth of a worm-wheel. Perhaps the finest circular saws made are those for slitting the nibs of gold pens. The exact size of one is shown in Fig. 56. It is $\frac{1}{200}$ inch thick, and makes 4000 revolutions per minute. The cut is engraved by using as a transfer the saw itself, kindly loaned by Mr. Eberhard Faber, of New York. * * * * *

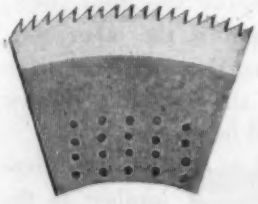


Fig. 54. Cutting Segment of Circular Saw.

Fig. 56. Saw for Gold Pen Slits.

For sawing *loaf sugar* circular saw teeth are ⋁-shaped, one-half inch apart, gauge No. 10, with great set. A 36-inch sugar saw runs only about 300 revolutions and under.

For *ivory* the teeth are ⋁-shaped, 12 points to the inch, with no set. These circulars are 2 to 10 inches diameter, and of from 19 to 22 gauge.

For *bone* a 9½-inch saw has 100 teeth, "handsaw" style in outline. The plate is 22 gauge, and an additional $\frac{1}{32}$ inch set is given.

For *iron* the handsaw tooth is used, with no set; space, 12 points; a 4-inch saw of 14 to 22 gauge runs 150 revolutions.

For cutting off wrought iron and steel beams Disstons recommend a circular 44 inches diameter and about ¼ inch thick, having peg teeth ⅜ inch apart, with no set, and running slowly where neat cutting is required—say only 150 to 180 feet per minute peripheral speed.

Richardson Bros. say that circulars for wrought iron should have a speed of about 150 linear feet per minute; for cast or malleable iron, one-fourth faster, or say 190 feet per minute.

For *white or Britannia metal*, one-fifth the revolutions for wood (say 1800 feet per minute), but a larger tooth than for iron.

For *brass*, as fast again as for iron—say 300 to 375 feet per minute.

As regards the question of few or many teeth for wood cutting,

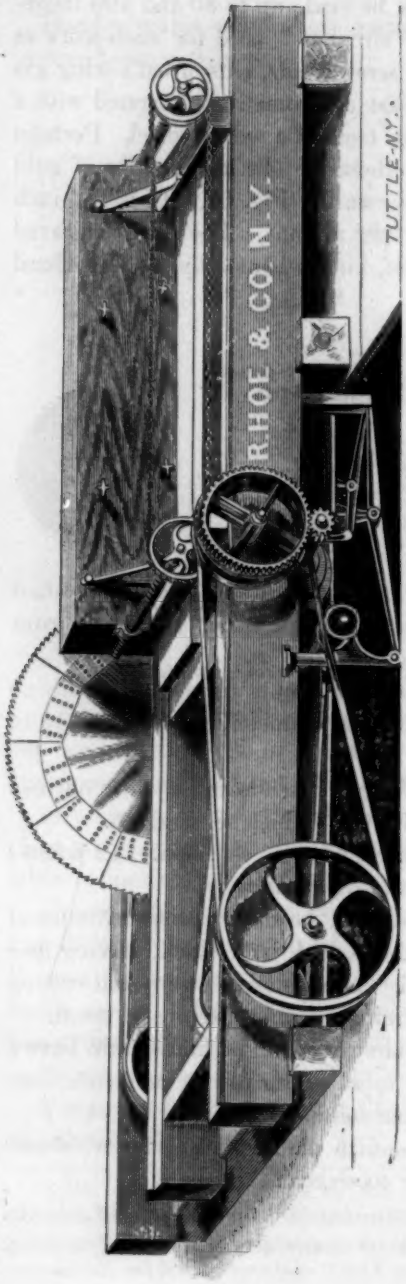


Fig. 55. Veneer Sawing Machine.

opinions differ, and yet perhaps without cause. The writer inclines to the belief that while the fewer the teeth the higher the feed capable per tooth, and the more chisel-like the action of the teeth, — yet there are cases where by reason of light power and hard cut more teeth are necessary. Certainly thin saws require the most teeth; or, to put it the other way, increasing the number of teeth enables the use of a thinner saw and less power.

Fineness of teeth also gives smoothness of lumber, as the teeth are stiffer and less likely to lead into the wood, and the saw marks are closer together than with many teeth.

In some parts of our Southern States where formerly a 56-inch circular had but 26 to 28 teeth now there may be found a very large proportion of 56-inch disks with 56 teeth.

The fewest number of teeth we know of in a rotating saw is *two;* there being simply two long arms with a central hub, revolving on an arbor, and chiseling their way quietly and slowly through a log. This could hardly be termed a "circular saw," being rather a rotating chisel, and much like the Daniels planer used in car shops. * * * *

In times past the grinding process was so difficult and expensive that the flat "circular" was finished on the log side only. Nowadays many makers give the same accurate finish on both sides, and the saws can consequently be used either right or left "handed."

A variety of the circular saw is the *dished* circular, Fig. 57, used not for dividing material in a right line, but for cutting out beveled-edged disks, as barrel heads. Its action thus comes in between that of the circular and that of the cylinder saw. * * *

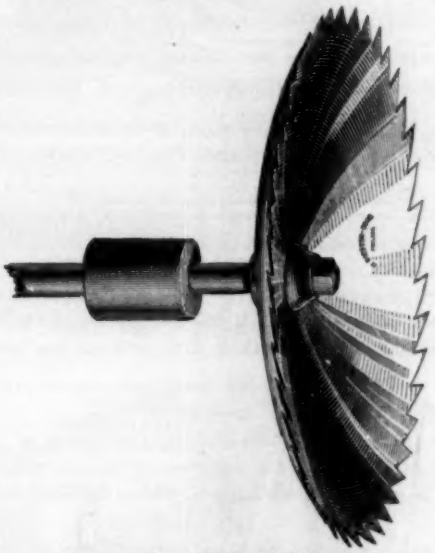


Fig. 57. Dished Circular.

Inserted-toothed circular saws, the use of which is already large and rapidly extending, have the following advantages over solid:

The teeth being drop-forged, from bar steel, are regular in size and shape, and of better material than is possible to use for the whole saw.

The teeth are capable of having more and better-shaped throat—a special advantage for coarse feeds, and for soft, wet and fibrous woods.

They cut so much smoother lumber that they are frequently spoken of as "planer-bits."

They effect a great saving in time and files and blades, over gumming and sharpening; they also avoid lessening the capacity of the saw by the reduction in diameter consequent on filing the solid saw.*

* Cost of Running Planer-toothed Saws, as compared with Solid-toothed Saws.—Messrs. Emerson Smith & Co. give the following calculations:

The widely operating and successful use of emery wheels is, however, lessening this advantage.

The time of the mill lost while the solid tooth saw is being re-gulleted is important in new countries and in locations far from the saw factory—as New Zealand.

With a few thousand little "bits," costing three cents each, a New Zealand or far Canadian sawyer is independent of mishaps, even with the knottiest wood.

There is an avoidance of the necessity of readjusting and aligning the saw on the mandrel in the case where a spare saw enables the sawyer to save the otherwise inevitable stoppage of the mill in the case of a tooth breaking.

The spacing, set and shape of the inserted teeth is better than the

---

"The average size of board circular saws is about 56 inches in diameter, so that we will base our calculations on that size.

"Circular saw mills vary in capacity from 5000 to 40,000 feet of lumber per day, 10,000 feet being about the average.

"Starting with a new 56-inch saw, at 10,000 feet per day, we will base our calculations on sawing 1,000,000 feet in 100 working days, or about four months.

Cost of 56-inch solid saw, present price list	$117 00
One hour per day for filer, 100 days, 30 cents per hour	30 00

"In order to reduce the size of a 56- to a 54-inch saw, a strip of tempered steel, 14 feet in length, 1 inch in width, and the thickness of the saw, must be filed into fine dust. Besides, time is spent in spreading and setting the teeth and in rounding the saw.

1 dozen 14-inch mill files per month, at $9 per doz	$36 00
Gumming and straightening once in 2 months, say	15 00
Average cost of transporting to saw maker, say	6 00
Reduction in size of saw, say 2 inches, leaving the saw at the end of 4 months 54 inches in diameter, present price list, $96, reduction in value	21 00

"The above calculation estimates the reduction in the size of the saw at only one-fiftieth of an inch per day. If the saw is kept gummed down with a file, the cost of files and filing will be much greater than this estimate. If a gummer of any kind be used, add cost of the machine, wear of tools, wheels, etc., and the owner will find the cost more than the estimate of sending it to a saw maker.

Cost of mill standing idle, say half hour per day, in filing and putting saw in order so that the owner has lost the sawing of 500 feet of lumber per day, at $2 per 1000 cost of sawing for 100 days	$100 00
Total cost	$325 00
Cost of planer, saw and 1000 bits	200 00
Difference in favor of Planer Saw	$125 00

average sawyer would maintain even with the "guide lines" marked in the disk by some enterprising makers. (See Fig. 60.)

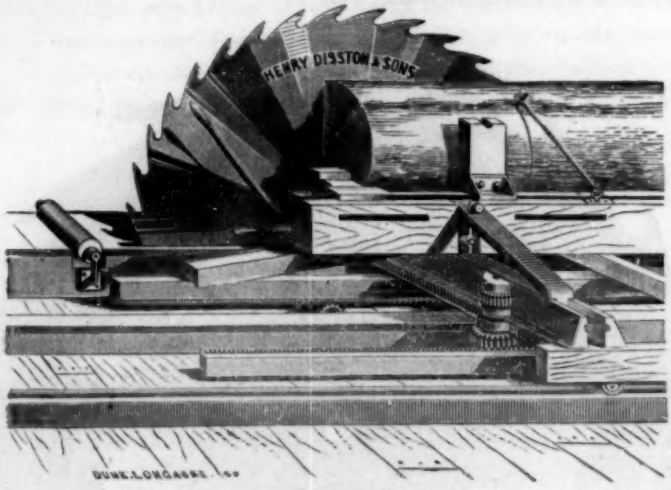


Fig. 58. "Right Handed."

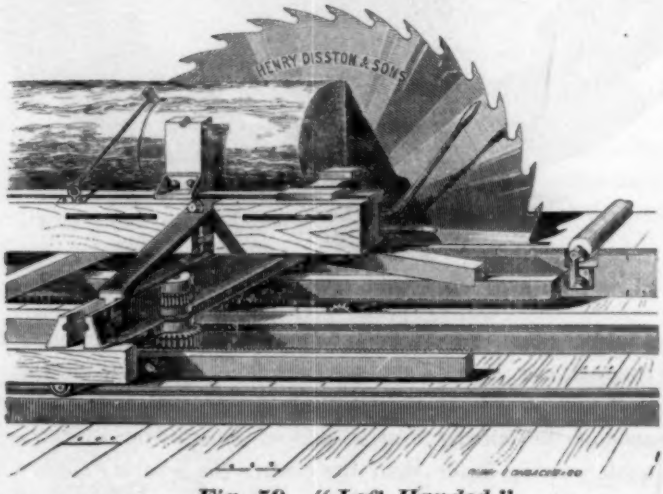


Fig. 59. "Left Handed."

Men capable of putting solid saws in order are very scarce. But in many mills are to be found men who are good, valuable sawyers, and understand turning out lumber to the best advantage, but who are poor filers. The inserted tooth makes their skill available.

The plate of a saw is nothing but a handle carrying the teeth, and is strained by the use of dull teeth. The inserted teeth can be kept sharp and hence strain the plate less.

Fig. 60. Showing Guide Lines.

The cutting points or saw bits being shaped and sharpened while out of the saw, can, if it be the sawyer's fancy, be made slightly concaved on the under side, thus presenting full prominent corners a little in advance of the cutting centre; and in consequence of the corners of all teeth wearing faster than the centres the separate teeth will do more work with one dressing, than solid teeth, which are filed or dressed square. Fig. 61 shows their first state and mode of wear. They represent a top view of the points of teeth in various shapes. If the point of a tooth gets into the shape of A or any other irregular shape, it should first be squared and filed up into a regular shape, so

that there will be an equal amount of metal on each corner. If a tooth loses a corner like that of B, the opposite corner should be filed off so as to have the appearance of C; swage it into shape like D, then bring it into a proper shape like E. A is also a bad tooth, having too much metal in one corner, and must be filed into the shape of C before it will spread properly.

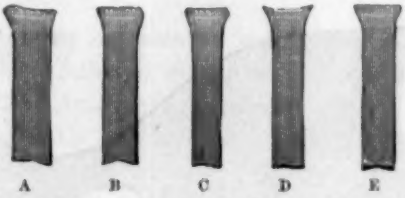


Fig. 61. Various Conditions of Teeth.

One file will go as far in keeping a good inserted tooth saw in order as ten with a solid saw.

An inserted-toothed saw can have hard or soft teeth at will, for varying kinds of lumber.

The Emerson bits are tempered to scratch glass, and weigh one-sixth ounce each.

The various items of power-saving by reason of keenness of cut and narrowness of kerf, are the same as are fully laid down on another page.

Inserted saw teeth came into use about 1840, the teeth being placed in rectangular sockets and held in place by a $\vee$ tongue and groove. The rectangular sockets have been largely discarded for curved, as giving less liability to crack.

The following figures from the Albion Mill on our West Coast, show the performance of the Hoe chisel bit saw:

	No. days.	Feet Board Measure.
November,	26,	859,407
December,	23,	798,274
January,	26,	866,992
February,	25,	852,818
March,	25,	962,537
April,	26,	934,337
May,	10,	387,019
	162,	5,661,385

Number of bits used in the work, 4000 in all.

The bits are run in the Albion Mill as follows: Starting in the morning, with new teeth, on 4-inch feed, in hard pine or red-wood until noon. Then a set of new teeth run until night. At night the watchman puts in the next set. The dulled teeth are sharpened twice for the bottom saw and are then worked in the top saw. * *

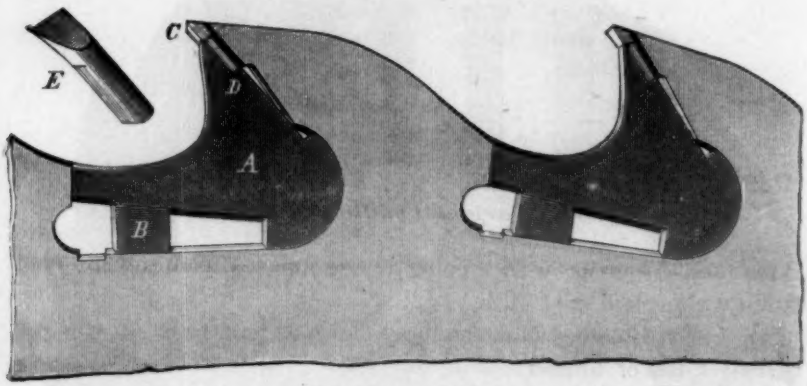


Fig. 62. Emerson's "Planer Bit."

Inserted toothed saws are made from 13 to 6 gauge, and from 12 to 72 inches in diameter, the smaller sizes being used for edgers and gangs.

Distribution of Atmospheric Pressure.—L. T. de Bort calls attention to the fact that in two columns of air, which have the same pressure at the surface of the ground, if the temperatures are different the decrease of pressure at higher levels is slower in the warmer column. Hence results a tendency of the air to pass from the warmer to the colder column, accompanied by a falling barometer in the former and a rising barometer in the latter. The effects of difference of temperature being generally opposite to those of barometer pressure, the transfer of air may be effected in the upper atmosphere, even when the pressure is lower at the bottom of the column. The ocean currents, in winter, augment the energy of the atmospheric disturbances by increasing the opposition which already exists between the continental and oceanic temperatures.—*Comptes Rendus.* C.

ENGRAVING.

A Lecture delivered before the Franklin Institute, March 8th, 1880.
By JOHN SARTAIN.

The art of engraving on metal is unquestionably of very ancient origin, and must have followed closely on the discovery of the art of working metals themselves into articles of use.

The desire observable in all men, including the most barbarous races, to adorn their implements and costumes with ornamentation of one kind or other, whether color stains, carving, or incised lines, proves that a love of art is universally innate in human nature. Almost as soon as man had learned to make out of iron, or other metal, a sword, he would seek to embellish its handle, at least, with ornament in the nature of chasing or engraving. Thus must the art of engraving have become a familiar every-day affair even in pre-historic times. In the book of Genesis two men are named (Bezaleel and Aholiab) as being "filled with wisdom to work all manner of work with the graver," and in the other writing attributed to Moses we read these words, "Take now plates of gold, and engrave thereon, as in the engraving of a signet, 'Holiness to the Lord.'" This form of expression indicates a practice quite well known at that time.

But the art of engraving on metal plates for the express purpose of printing from them with ink on paper is quite a different matter, and is of a comparatively recent date. In the year 1452, a goldsmith of Florence, Italy, named Tomasso Finiguerra, made an impression on paper from a silver pax he had engraved for the Church of San Giovanni, of that city, the subject being "The Crowning of the Virgin." This pax still remains among the valued treasures of that Church of St. John, and the precious print from it is carefully preserved in the French National Library at Paris, where it was discovered by Zani in November, 1797. The pax itself was ordered from Finiguerra by the Consuls of the "Company di Calimala" in 1451, and the proof (a fac simile of which you see before you on the screen) was printed from the finished work before the artist introduced the niello into the engraved lines, as was the practice of the goldsmiths of Italy of that period. All this is authentic, and establishes beyond

controversy that to this Florentine artist belongs the honor of having originated the art of plate printing.

In addition to the fac simile of the *undoubted* print by Finiguerra, I ask your attention to fac similes of two other prints that have been attributed to him: one, a Madonna, with the infant Saviour on her lap, and surrounded by numerous figures; the other is the circular print of the Gray collection (now in the Art Museum of Boston), and which has the arms of the Medici family sketched with the pen in the middle space. In the absence of all other evidence than that of style, I should say that it is the work of Baccio Baldini, after a drawing by Sandro Botticelli. If this print belongs to the early period ascribed to it, the Medici shield must have been inserted long afterwards, because the arms of that family used to have but five pellets, while the drawing on the print has six, as you see. The change from five to six occurred as late as 1533, when Catharine di Medici was married to the Dauphin of France., one of the stipulations of that arrangement being that a sixth pill, decorated with the French fleur-de-lis, should be added. The Medici, you know, were noted money lenders, and our modern pawnbrokers hang out *their* sign, but with the number abbreviated to three and those gilded. This fac simile of the Boston print was engraved about seventy years ago, by my father-in-law, Mr. John Swaine.

It was the custom of these artistic goldsmiths to fill in the lines of their engraving on silver with a semi-metallic substance called niello, which is a compound of copper, lead, oxidized silver, sulphur and borax. These were melted and thoroughly mixed together, and after cooling were crushed in a mortar into a fine powder. The plate was cleaned in a way that Benvenuto Cellini describes, and the powder spread over it. Heat was then applied from below, when the niello would melt and flow down into the lines at a temperature much lower than that which would affect silver. When cold it was ground down to the level of the silver surface, and the work was complete.

Before putting in the niello, Finiguerra was in the habit of filling the lines of his engraved plate with black and grease, and making an impression by pouring on to it melted sulphur. It afterwards occurred to him that this might be done on paper, by the aid of a roller, if sufficient pressure could be brought to bear upon it; he tried it and succeeded, but was for many years far from appreciating the value and importance of his discovery. It was not until about the year 1460

that plates began to be engraved for the express purpose of being printed from.

Engraving on wood was practiced in China many centuries before it was known or used in Europe, and whether Italy or Germany has the best claim to the honor of the invention, or of the earliest productions in this line of art remains an unsettled question, the preponderance of evidence being rather in favor of Germany. It is true there is record of a series of nine wood-cuts that have disappeared and have been sought for, thus far, without success. They are described by one who saw them in the year 1720 as representing eight scenes in the life of Alexander of Macedon and a frontispiece, in which last is a dedication to Pope Honorius IV. They were designed and engraved by the two Cunio, twin brother and sister, when but sixteen years old, and who lived at Ravenna in 1284–5 while executing these works. These prints may not have passed altogether out of existence, and may yet be found some day—possibly in the great Vatican library, since, having been inscribed to the artist's relative, the Pope, a copy was, without doubt, presented to him. He who has the good fortune to happen on these cuts will have as much reason to rejoice as did the Abbate Zani when he found the Finiguerra print in the library at Paris. Such a discovery would secure the claims of Italy to priority in *wood-block* printing, as well as that already conceded of *plate* printing.

Thus we see that line engraving on metal was practiced long before it was imagined that it was capable of being used to print from, but, on the other hand, we see that engraving on wood was originally devised for the express purpose of being printed from. The origin or first use of the latter in Europe is veiled in obscurity, and even if the Cunio prints should be met with, it would still remain uncertain how much had been done prior to their date. Pope Honorius IV, to whom those cuts were dedicated, governed the church but two years, from the second of April, 1285, to the third of the same month, 1287, an epoch anterior to all books printed in Europe that have hitherto been found. But, before books were printed, engraved blocks of wood were used for printing playing cards and other matters, and this may have suggested the idea of engraving entire pages of words on single blocks, which, in turn, gave place to the further improvement of movable types.

That wood engraving was already extensively practiced in Venice

before the year, or at least as early as the year 1400, is evident from the following decree of the Venetian government in 1441, at which time the art is described as having fallen into almost total decay, owing to the too abundant importation of foreign productions in this line.

"MCCCCXLI. October the 11th. Whereas, the art and mystery of making cards and printed figures, which is used at Venice, has fallen to total decay; and this in consequence of the great quantity of playing cards, and colored figures printed, which are made *out* of Venice; to which evil it is necessary to apply some remedy; in order that the said artists, who are a great many in family, may find encouragement, rather than foreigners. Let it be ordered and established, according to that which the said masters have supplicated, that from this time in future, no work of the said art, that is printed or painted on cloth, or on paper, that is to say altar pieces (or images) and playing cards, and whatever other work of the said art is done with a brush and printed, shall be allowed to be brought or imported into this city, under pain of forfeiting the works so imported, and xxx livres and xii soldi; of which fine, one-third shall go to the state, one-third to the Signori Giustizieri Vecchi, to whom the affair is commited, and one-third to the accuser. With this condition, however, that the artists, who make the said works in this city, may not expose the said to sale in any other place but their own shops, under the pain aforesaid, except on the day of Wednesday at San Paolo, and on Saturday on San Marco, under the pain aforesaid."

Then follows the subscription of the Proveditori del Commune, and that of the Signori Giustizieri Vecchi.

The effect produced by this law of protection was all that had been expected. The art revived, and afterwards flourished to the extent, that, in addition to supplying the home demand for prints of the kind described, they commenced pirating the works of their neighbors, underselling the foreigner as the foreigner had before undersold them. Albert Durer suffered so much in this way that he made the *then* tedious and hazardous journey across the Alps from Nuremberg to Venice, to obtain redress from the authorities if possible.

I will now endeavor to describe the several processes of engraving in the order of their invention. They are seven in number. Engraving on wood, line engraving on metal (which includes etching) mezzotinto, aquatinta, soft-ground etching, chalk or stipple, and lithography. All these are wrought by skill of hand of the artist, and stand apart

from those productions of the actinic property of light on sensitized films, made by the aid of the camera. These heliographic works are very beautiful, but are outside the province of this discourse, which is devoted to hand work only.

In wood engraving an artist first makes a drawing on a block of well-seasoned box wood, cut crosswise of the grain, and of about seven-eighths of an inch in thickness, corresponding to the depth of printer's type, because the engraved cut is frequently inserted among the set-up types to be printed along with it. The smoothed side of the block is prepared for drawing on by rubbing into the grain the white facing composition on enamelled cards, moistened, or with flake-white. At one time it was the custom to impart a tooth to the surface, for the freer delivery of the lead pencil stroke, by using bath brick finely powdered and moistened with water, and, when dry, smooth with the palm of the hand. The engraver then cuts away the wood between the lines of the drawing, leaving the wood standing on which the lines are drawn, and which are to receive the ink from the printer's roller, for the process of printing from a wood-cut is the same as from type, and by means of the same character of press. It is a surface printing and the ink used has to be of a consistency, and only in such quantity, as to deliver where it touches and not flow down into the engraved lines and dots, but rest only on the face of the lines and points left standing. This is exactly the reverse of the process of printing from an engraved copperplate, in which the incised or sunk lines are what must be filled with ink, and can only be made to deliver to the paper by means of a very severe pressure of the roller press.

The instruments used are gravers, tint tools, scoopers or gouges, and chisels or flat tools. The graver is used in the manner of a plough, and being driven forward ploughs out a furrow, delivering the material removed freely up the face of the graver. To economize time flat tools are employed in the wide open spaces. I abstain from the affectation of using the French word *burin* because the plain English word graver is better and more expressive.

Sometimes it may happen, through accident or error, that it becomes necessary to work over again some part. The remedy then is to introduce a fresh piece of wood into the defective place. A circular hole is drilled nearly through the block, of a size sufficient to cover that which has to be obliterated, and a nicely fitting plug inserted. It is then levelled exactly and the part re-engraved.

Chiaro oscuro drawings on tinted paper, having the high lights touched in with white chalk, are easily imitated in wood engraving by using a second block with the high light cut out. Suppose this tint block printed first with ink of a grey color and the picture-cut afterwards printed over it with black, an appearance will be produced of a drawing done on grey paper with the high lights touched in with white.

There is in Vienna an art publishing club a good deal interested just now in attempts to revive this practice of chiaro scuro engraving on wood, by which in old times very effective work was done by the use of two or three blocks. Mr. Baxter, of London, produced beautiful prints in oil colors by printing the successive tints from different engraved blocks. These effects have since then been rendered by the art of chromo-lithography.

Quite a revolution in the art of wood engraving has occurred in this country in the last few years, and is the result of the use of photography for placing on the block the drawing to be engraved.

By the introduction of this method copies of large drawings and boldly executed sketches are transferred to the surface of the block previously sensitized for the purpose—with a minutenss of detail altogether beyond the power of an artist's hand to draw. This naturally necessitated a corresponding minuteness of execution with the graver, at the same time, however, leaving little room for the display of the engraver's skill in freedom of flowing lines. In the old style the direction given to the line aided in expressing foreshortenings and the perspective of rounded forms, and our admiration was frequently excited by examples of masterly graver cutting. In the new school we have what may be by many considered better, the manner of the original artist copied is *more* prominent, the manner of the engraver *less* so. About the best work done anywhere at this time is that produced in New York, and this is not disputed even in Europe. The famous engraver, Thomas Bewick, of Newcastle, England, to whose labors is due the revival of the art toward the end of the last century, would not have believed it possible to engrave and print such cuts as are now published monthly in the city of New York.*

Line engraving on metal plates for the purpose of printing dates back to 1460, as we have already seen, eight years after the print was

* Numerous original examples were exhibited and referred to in illustration of the history and progress of the art, from Albert Durer, Burgmaier and others, down to the manner of later times.

taken by Finiguerra from his Pax of the Crowning of the Virgin, although that print is believed to be far from the first of his printing, which some writers place as far back as 1440, only that Pax has a certain known date, 1452. Among the engravers who preceded Marc Antonio Raimondi the most prominent were Sandro Botticelli, Baccio Baldini and Andrea Mantegna, but these were not equal to Marc Antonio, whose works eclipsed all that had been done before in that line. He engraved a great many plates from the pictures and designs of Raffaelle, and that great artist took great interest in the work and corrected the outlines on some of the plates with his own hand. A fine example of this engraver's best work may be seen in the print of Poesy after Raffaelle, seen on the screen. This is not the original, but a very accurate fac-simile copy.

The mode of procedure at this stage of the art was extremely simple, and called into requisition only four tools, a graver, scraper, burnisher and steel point.* The clean, polished surface of the copper plate is covered with a thin film of white or bees' wax, spread while the plate is just warm enough to melt it. When the plate has cooled, the outline drawing or tracing is transferred to this slightly adhesive surface by pressure. This process reverses the subject, which is an advantage, for all engraving intended for printing must be the reverse of the way it is intended to be in the print. The forms are then faintly scratched through the wax with the steel point. Then the plate is warmed and the wax wiped off. All the outlines and shades are then cut into the plate with the graver, and the rough barb or burr that hangs to the edge of the plowed line is removed by means of the scraper. When a proof impression has been taken by the printer, it may, perhaps, be seen that some lines have been cut deeper than is desirable, and others not deep enough. This is corrected by re-entering the faint lines and cutting them broader, and those that are too black are crushed a little with the burnisher. The plate is rubbed with oil and a roll of flannel, and is finished.

By this extremely simple process were engraved those superb examples of this kind of work done by the graver alone, without etching, which I direct your attention to on the screen. First, there is the print by Paul Pontius, the Fleming, after Vandyke, of the "Dead Christ and the Marys." In this style I cannot imagine anything

* These tools were exhibited and their use explained.

finer. Correct in drawing and definition of form, faithful to the style and characteristics of the master, and with a confident freedom of graver line that is marvelous, and yet not obtrusive. And this masterpiece is wrought without the aid of the local tints and the charm of chiaro oscuro, but simply by the light and shade of the objects in the picture, for it was not then known that the engraver's art was capable of giving all the qualities that a picture possessed except its color.

The next is a dashing piece of graver work by Bolswert, the Hollander, conveying an idea of Rubens' style remarkably well, although by such coarse means: and lastly, in this class of work with the graver, the group of Angels supporting the Tuscan Diadem over the arms of the Medici, after a fresco by Pietro di Cortona, in the ceiling of an apartment in the Pitti Palace, in Florence. I believe this to be by the French engraver Claude Mellan. It is almost all done with one line, without crossings, and is a brilliant example of that peculiar style.

I will now endeavor to explain the process called etching, the invention of which has been vaguely and erroneously attributed to Parmiggiano, who, besides being an admirable painter, was an alchemist, and wasted his substance and his health in trying to discover the philosopher's stone, in which unfortunate pursuit he is supposed to have fortunately happened on this method of engraving. But it is quite certain that the etchings by this artist were done long after Albert Durer had practiced the same art in Nuremberg, and, so far as we know at present, Germany must be credited with this admirable invention. In describing the process I will direct your attention to examples of the different kinds of work belonging to this group.

The foundation of the art is this, that acids corrode and eat into the metals, while resins and bitumens *resist* the action of acids. Therefore, if you cover the face of a copper or steel plate with a varnish of this nature you effectually protect the plate from the acid. If after having done this you scratch lines or dots through this protecting coating with a steel point, the acid gets access to the metal in those parts and corrodes it so deeply that, after the varnish has been removed by the aid of spirits of turpentine, these lines can be filled with printer's ink and will hold it the same as if they had been cut in with the graver, and a little better too. And this is etching. The varnish coating is called etching ground, and is compounded of asphaltum of Judea, Burgundy pitch and white wax, and is spread on the plate by means of heat.

Fig. 42. Largest Shingle Machine in the World.

The Burgundy pitch has the property of causing the compound to adhere tighter to the plate, and without the tempering wax the point would not cut so smooth a line through it. Your ball of etching ground is tied up in a piece of strong silk, the plate on which the ground is laid, having been made perfectly clean and free from grease, is held by a hand-vice and heated over a gas flame, or some other way, until it is hot enough to melt the etching ground, so that it comes through the silk on to the plate; then, with a soft dabber covered with fine silk or with kid leather, it is distributed evenly over the surface of the plate by dabbing, or on that part where your work is to cover. While it is still hot it must be held face downwards and smoked black by means of a flame from a torch made by several strands of wax taper. Without this blackening of the etching ground its semi-transparency would prevent you from seeing your work as you progress. The plate being cold you transfer your outline drawing or tracing by pressure, and proceed to make your etching with a steel point, just the same as you would make a pen and ink drawing on paper, but your hand must be kept from resting on the plate by a bridge, which may be made by a thin board resting on a book on each side of your plate; but engravers have a strip of wood fastened at each end of the etching bridge. Your etching done, it is bit in with aquafortis, a mixture of one part acid and about three parts water, nitrous acid being used for copper and nitric acid for steel. Hard steel bites better than soft. The work must now have a bank of walling wax built around it with a spout formed in one corner, and while moulding it into shape with the thumb and finger, take care to press it perfectly close down to the plate lest the acid should get under it. The bubbles that form on the lines during the biting must be swept away with a soft feather. In two or three minutes the aquafortis should be poured off into a wide-mouthed bottle and water instantly poured on, the work feathered as before to clear it from acid, the water poured off, and the plate dried with blotting paper or a soft rag tenderly pressed on it. The strength of the line can now be ascertained by scraping off a little etching ground on some light part. If found to be deep enough, paint over all the first grade of light tints with any kind of varnish that will harden quickly. English engravers use Brunswick black (I use red sealing wax dissolved in alcohol). This is called by engravers stopping out. Put on the same acid again, and bite the next darker grade of tints; operate as before and then bite in the third gradation, etc.

The gradation of tints need not be left *altogether* to the successive bitings, as by etching the dark parts of your plate with a stronger and broader point, and a firmer exercise of the hand, the biting of those parts is hastened.

The etching ground is now removed with spirits of turpentine and the work rubbed with oil and a woolen cloth, called the oil rubber, and then a proof taken by the printer. Where the lines are bit too dark bruise them down with a burnisher; where they are not dark enough you can either re-bite them or re-enter them with the graver. If you re-bite, dissolve some etching ground by heat applied under the plate—on the margin, if you have a broad one outside of your subject. If there is not an empty space on your etched plate large enough, you take a separate plate and, having heated it sufficiently to dissolve etching ground, you feed your dabber from this store, evenly spread, and deliver it over that part of your etching that is to be re-bit, which must be heated just enough to take the etching ground from the dabber on to itself. This is a most delicate operation and requires a steady hand, for the etching ground must be delivered only on to the *surface* of the plate between the lines and dots and none suffered to get into the work already bit. As this is not smoked you are able to see the strength of line you are obtaining while the biting is going on, and can stop it just when it is deep enough, according to your judgment.

Whatever addition you desire to your work of lines, more tender and delicate than the faintest of your etched lines, is produced with what is termed the dry point, that is, abstaining from the further use of acid, you scratch in with a point all the fainter tints of your picture and remove the burr only to just that extent that a printer's proof from your plate shows to be necessary. I will now point out the different styles of etching from the fine examples here displayed before you.

Some of these painters' etchings are what have been termed dry etchings, that is, they are, as you see, printed clean, without burr, and resemble a pen-and-ink drawing on paper. Such are those by Bergham, Salvator Rosa, Callot, Mortimer, Vandyke, Angelica Kauffmann, Ruysdal and others, and, contrasted with them, a class of etchings that depend much on skilful printing, having their darks massed and emphasized by blurring over the ink from the deeper lines so that no clear white paper shall appear between them. Of course the

Fig. 42. Largest Shingle Machine in the World.

impressions from plates printed in this way are variable and uncertain, and some etchers escape being at the mercy of the printer by roughening the surface of the plate over the darks to make it hold the ink, and by spreading it obtain middle tint at the same time. Sometimes this tint is produced by corroding the plate, and sometimes by mechanical abrasion. It has been said of aquatinta engraving, that it was invented by the evil one expressly to torture those who practice it, and the same may be said of blurred etchings as an exquisite torture for plate printers.

During the past few years there has been gradually growing a passion for etching, and quite lately it has intensified into a perfect furor. Eminent artists, who know what they are aiming at in certain effects, are producing works in this way that the world will not let die; but, unfortunately, there are many who have not yet acquired a knowledge of the simplest principles of art, have also caught the infection and joined in the hot pursuit, and

> As their imagination bodies forth
> Things without form, they give their airy nothings
> A local habitation and a name.

I fear that I have dwelt so long on this branch of my subject as to exhaust the patience of of my audience; but I have desired to explain as fully as I could the *modus operandi* of etching and satisfy many inquirers at one time. The prevailing epidemic reminds one of some lines by Alexander Pope, which, by slight modification, are applicable to the present state of things.

> "Shut, shut the door, good John," fatigued, I said,
> "Say that I'm absent—say I'm ill—I'm dead!
> The dog-star rages, and 'tis passed a doubt
> A Bedlam full of etchers is let out;
> Fire in each eye, and etchings in each hand,
> They rave o'er proofs, and madden round the land."

Having now gone through with work done with the graver alone, and also with that done with acid and the point alone—each pure and simple—it is necessary to say something of the achievements—the triumphs of the engraver's art, produced by a combination of these two methods during the past two centuries, and I am happy to have it in my power to illustrate this branch of my subject by rare impressions of engravers' progress proofs of many important plates. I show you only a few now, as they will suffice for the purpose, and there is not room for more.

Alongside of these proofs of the etched state of the plate you see impressions of the same plates in the finished state, and they present through the eye a clearer statement of the method of procedure than I can convey in words. Take, now, this admirable plate by Robinson of "the Wolf and the Lamb," after Mulready, which, of its kind, may be regarded as a perfect work. The broad masses of dark, you perceive, are all laid in with the etching point and bit in, as are also such portions of the light as demanded the peculiar character of line which a graver cut cannot give. Such is the work on the broad mass of light on the fence in the foreground and the ground itself on which the figures stand, which latter is full of a character which could not possibly have been given with the graver. The lights of the drapery and all the flesh tints are left to be done with the graver, and by examining the two impressions together of each of the plates shown, you will come to understand the method of procedure in a general way. The etching and finished print of "Mercury and Argus," after Turner, and those of the "Temple of Jupiter at Egina," from the same painter, show this difference in treatment, that, being landscapes, there is a good deal of dry point work in the light tints, and as little graver work as possible. Where you see an etched tint fainter in the first than in the finished state, it has been darkened by rebiting; where it is too dark it has been reduced by crushing down with the burnisher, only, in the case of etched draperies, the darkening is done by re-entering with the graver rather than by rebiting. You will observe that where a dark drapery is etched, having a dark background also etched, the lines invariably stop short of the outline, leaving a white space like a chalk line. These lines are left to be carried forward to the boundary by the graver, because if done with the etching point they would all bite into a blot, since the curve they must take as they approach the edge brings them crowding nearer together; therefore they have to taper thinner and thinner, which can only be done with the graver.

But time presses, and I must rapidly close this branch of the subject without doing justice to it. One fine print you see, the "Massacre of the Innocents," after Le Brun, is only half a print really, and shows what has sometimes been done when a plate is inconveniently large. You see that the left side, as you view it, has a waving and not a straight boundary like the other side and top and bottom, because it is the middle of the subject, and has to be joined to the

Fig. 42. Largest Shingle Machine in the World.

other half. The other half is in the Phillips collection, belonging to the Philadelphia Academy of the Fine Arts.

I think you may see before you now the perfection of work in line engraving and etching. The flesh tints in the plate of the "Princess Charlotte," after Lawrence, by Henry Golding, have certainly never been surpassed, and I doubt if they were ever equaled, I mean particularly the head, neck and bosom, and left arm and hand. This plate was four years on the engraver's table; he worked till he was eighty, and yet you will not find his name in any of the dictionaries of engravers, although you will find hundreds that are of little or no account. I cannot imagine it possible that Leslie's picture of "May-day in the Reign of Queen Elizabeth" could be better engraved than you here see it in the print by J. H. Watt; but who ever hears the name of Watt on the lips of those who talk about engraving? With regard to etching, Unger, of Vienna, is the prince of etchers, partly because of his unsurpassed execution, and partly because he gives the exact character of the painter he translates from. Look at that Ostade, that Ruysdael, Vanderwelde; and Rubens is so faithfully given in that triple print, that the very color is revived in the imagination. Then there is that triumph of the art in his copy of the gorgeous Makart "Catarina Cornaro receiving the Homage of Venice," the original of which was so lately lost to this country.

If Unger etched after Rembrandt, he would be even better than Rembrandt himself, whose extravagant coarseness in some parts of his plates it is only affectation to admire. If Rembrandt had possessed the use of mezzotinto for his peculiar effects, as John Martin had, what wonderful things he would have left us!

In the beautiful print before you, by Le Bas, after Teneirs, "the Distribution of Bread to the Poor," now in the Louvre, you see a remarkable union of the freedom of a painter's etching with the elaborate completion with the graver. It is a perfect copy of the painting, and it appears to me to be of the same dimensions.

Le Bas was French. The extreme opposite of his free style is that of Wille, who also flourished in Paris, but was of German birth. The print on the screen, copied from Schalken, is a fair specimen of Wille's style, which is mechanical and without feeling or artistic spirit; but his astonishing skill in the most exact and elaborate management of the graver in cutting pure silvery lines earned for him an immense reputation. His influence is of a kind that has caused it to be said,

"It would be better for the art had he never been born." Bervic was his pupil, but free from the faults of his master, and he with Edelinck, Audran, Drevet, Nauteuil and their like, raised this branch of French art to a high degree of perfection, and it is well maintained in this later time by such men as Henriquel-Dupont, Forster, Jules Francois and others.

The admirable engraving by Robert Strange, after Benjamin West, entitled "Ah! si quá Fata aspira!" was completed in 1786, and for it he received the honor of knighthood. I will narrate a story in connection with this print, in as few words as I can; it displays a mean malignity on the part of King George the Third, of England, towards this engraver, that is astonishing. Those who visit the Museum in the Philadelphia State House will remember a whole-length portrait of that king in his youth; it was painted by Allan Ramsay, son of Allan Ramsay, the Scottish poet, and is one of a number of valuable pictures, the munificent gift to the Pennsylvania Academy of the Fine Arts by Mrs. Joseph Harrison, Jr. Ramsay was painter in ordinary to the king, and therefore was often called on to repeat his portrait for presentations, so this may be a duplicate, or it may be the identical painting I have to refer to. It is all the same. The king sent word to Strange, through Sir William Chambers, the architect, that he desired him to engrave this picture of himself and another, also by Ramsay, of Lord Bute (who was a crony of his), and he should be paid one hundred guineas on each plate, and all the profits from the sale. The engraver declined, and gave as a reason that it would interfere with a project he had of going to Italy to copy and engrave certain pictures in public galleries there. This angered the narrow-minded monarch, and he commenced a system of the most malignant persecution against the engraver, and continued it for near a quarter of a century. All connoisseurdom knew of the king's displeasure, and the subscriptions to Strange's prints suddenly ceased. In Italy his steps were dogged by a man named Dalton, who was the king's librarian, and as soon as it was ascertained what pictures Strange intended copying, his plans were frustrated by an application from the agent, in the name of the king, to parties without whose permission copies could not be made. I will read you one of the certificates afterwards obtained by the engraver.

"We Vincentius Malvetius, Cardinal Presbyter of the S. R. C., Archbishop of Bologna, and Prince of the S. R. Empire, To all and

Fig. 42. Largest Shingle Machine in the World.

every one who shall see these presents, certify and attest; that M. Dalton, bookseller to the King of England, asked a permission from us, in the year 1763, to allow M. Bartolozzi to make a drawing for the said King of England, of the picture representing the Circumcision of our Lord Jesus Christ, painted by the celebrated John Francis Barbieri, Knight, commonly called Guercino da Cento; and we have granted M. Dalton's request, the permission was given accordingly.

"In testimony whereof we give these our letters, sealed with our usual seal, and signed by us at our Archbishop's Palace at Bologna, this 20th day of December, 1773.

"(Signed) Vinc. Card. Malvetius Archipiscopus.
"Paulus Canonicus Comes a Secretis."

It is needless to point out the mistake of the Italian in calling Dalton bookseller, instead of Librarian to the King.

This print by Bartolozzi, after Gurcino, is in the splendid collection of Mr. Claghorn, and was once exhibited in the annex alongside of the Academy building. Having defeated Robert Strange abroad, the next thing was to head him off at home, and for this purpose inducements were held out to Bartolozzi to make England his home, which he did. Drawings by Strange were rejected at the Artists' Exhibition under the excuse that they were colored, although those by Bartolozzi, of the same character, were admitted. In the formation of the laws of the new Royal Academy, under the patronage of the King, engravers were excluded, in order to keep out Strange, although Bartolozzi was admitted, an operation which the king understood, no doubt, although he is said to have been puzzled to know how an apple could get inside the crust of a dumpling.

Finally, West, the peacemaker, suggested the engraving you see before you, which being shown at Windsor, the painter obtained leave to bring Robert Strange with him to the royal residence. A complete reconciliation resulted, and from that time forth the plates bore the inscription, "Engraved by *Sir* Robert Strange."

It is possible that the King's animosity may have been intensified by the fact that our engraver had been a Jacobite, and out with the Scottish army for the Pretender Stuart, in 1745, when his career very nearly came to a close. After the battle of Culloden, Strange was being pursued by some soldiers under the lead of an officer, and was seen to take refuge in a house that stood alone. The men were posted around to render escape impossible, while the officer entered suitably attended.

The lady of the house was seated in the parlor, and to her the gentleman apologized for his intrusion, but said it was his duty to arrest the man who had taken refuge there. She told him that she had no right to object, and accordingly the search was made, but nowhere could the fugitive be found. The disappearance was most extraordinary. The officer again apologized and bowed himself out. As soon as it was perfectly safe, Strange emerged from his place of concealment, which was under the lady's ample skirts. She afterwards became Mrs. Strange, and this you will say is not *strange*.

The third style of engraving in the order of my list is mezzotinto, and its invention dates back to 1640 at least, as there is a print in this manner, bearing date 1643, done by Ludwig von Siegen. He and Prince Rupert were acquainted, and to the latter the invention has been credited by some, but whether rightly or not will probably never be known.

The leading characteristic of the process is pretty well described in an anecdote of the camp, true or false. It is said that Prince Rupert, in strolling through the camp, observed a soldier grinding out the rust from some piece of armor. Part was done and part not begun. This suggested to the mind of the general the idea of roughening a plate all over so as to hold printers' ink, and then to remove this in parts forming the lights of a print.

The surface of the plate is covered with myriads of dots by means of a mezzotinto grounding tool or rocker. It is (as you see) like a broad chisel of steel, scored on one side with fine grooves, equidistant and of equal depth. Thus is formed on the edge a row of projecting teeth, the end being sharpened at a bevel and curved, so that it can be rocked from side to side, held slightly inclined with the teeth on the plate and advanced forward between parallel lines while rocking. At every new covering the direction has to be changed, so as to avoid, if possible, going over in the same direction twice. When the surface is completely covered and made black with dots the ground is complete, and if a printer took a proof from it it would yield a perfectly black impression. The picture is then made by scraping away these dots down to the very bottom, where the pure high lights are to be, scraping them partly away for the middle tint, and leaving them as left by the rocker for the extreme dark. Formerly mezzotinto was used pure and simple, without a foundation of deep etching as now, and it derives its name of "mezzotinto," half tint, from the softness of its effect. But

Fig. 42. Largest Shingle Machine in the World.

at this day an etching is made, sometimes quite elaborate, before the mezzotint ground is laid, and it is intended that this should show through the mezzotint after the scraping is done. The mixed manner of line, stipple and mezzotinto is now the prevailing style in England, and has been for the past forty or fifty years, for framing prints. Line engraving continuing to be used for plates of smaller size, especially for book illustrations. Large line plates are seldom engraved, except for art unions, and there are instances of amateur clubs, composed of men of means, who subscribe money to enable an eminent engraver, like Mr. Doo, to devote himself to first-class work in this line.

I show you here a large plate by Samuel Cousins, after a picture by Sir Thomas Lawrence. It is a superb work, and is almost a pure mezzotinto; any one not blinded by prejudice must say that a more faithful translation of a painting could not be made. The drag and sweep of the painter's touch is imitated, as well as all the other qualities, except its color. The same engraver finished a mezzotinto plate last summer, of "the two Princes in the Tower" (from which the wood-cut I now show you was copied), and was paid more than eight thousand dollars for it. It was smaller than this plate of Pius VII. and there was not half as much work in it.

It will be conceded that there is no class so difficult to satisfy as the painters, and there certainly can be none better qualified to judge of what is most desirable in art. Now, the forty who constitute the Royal Academy at London had occasion, after the repeal of George III's vindictive regulation, to select one engraver as a representative of the entire profession—the whole art, irrespective of style—and the choice fell on the man of mezzotints, Samuel Cousens.

There is a confusion of terms among persons not over well-informed on art matters that needs correcting. For example, there are many, who, if asked what these line engravings are will promptly answer "those are steel engravings." Next ask them whether these mezzotints are also steel engravings, they will answer, "No, of course not; they are mezzotints; they're not steel." Now the fact is those mezzotints *are* steel engravings, and the others are not. Mezzotints are *always* done on steel, and line engravings are frequently done on copper. All that are seen here, except the mezzotints, are copper. There is no sense in the term "steel engraving." It expresses nothing of style, and the fact of a work being done on steel ought not to be a

recommendation, for it makes it none the better, except to the publisher, who can get from it a larger number of impressions.

The printing of mezzotints, when done rightly, is different from line printing, and the two styles ought not to be carried on in the same printing office, because the material and the method used in line work is so much easier than the other that the men are sure to use both for mezzotints. This is what brings the style into discredit—bad printing—and publishers go so earnestly for the cheap that the prospect is hopeless. As Thomas Carlyle says, "cheap and nasty," and the latter is accepted for the sake of the former.

Plate printers' ink is made by grinding a fine kind of charcoal into linseed oil that has been burned and oxidized until it will draw into unctuous threads between thumb and finger. Lampblack, such as is used in woodcut printing, won't do at all. The best and only proper black is made from the skins and seeds of grapes after the juice is pressed out for wine. Manufacturers of Mayence and Frankfort buy up this material, burn it and grind it, and it is called Frankfort Black; and these Frankfort manufacturers supply all places in the world where good work is done. During the first Napoleon's war with England the commerce with the continent was cut off, and English plate printers could not obtain Frankfort Black. Then the Society of Arts offered a liberal premium to any who would produce a black having the quality of Frankfort Black and to be no dearer. They continued the offer for at least twenty years after the continent was open to their trade, but the want remained unsupplied. In good printing, with the proper black, the print should appear, on looking along it towards the light, like black velvet on white satin, the hot polished plate giving a satiny polish to the paper, while the ink stands up from it like black velvet.

Impressions from plates engraved in the style termed "aquatinta" resembles in appearance an India ink or Sepia drawing, according to the color of the printers' ink used in printing. The invention is attributed to a French artist named St. Non, and a little later than the introduction of mezzotint; it was successfully practiced by a German lady, Madame Catharine Prestel. It was introduced into England by Paul Sandby about the middle of the last century.

The etching ground in this method is resin, and in France is spread on the plate in a shower of fine powder, and then fixed as it falls by means of heat applied from beneath the plate. The English method

Fig. 42. Largest Shingle Machine in the World.

is to dissolve the resin in alcohol and pour it on to the plate. When the alcohol has evaporated the resin is found in small granules all over the surface, with fine cracks between them, leaving the copper thus exposed so that when aquafortis is applied it will corrode the plate at these cracks and not where the grains of resin adhere. The guide lines of a tracing or outline drawing are transferred on to this resin ground, a banking wall of wax with a large spout at one corner is formed on the margin around the subject, and the high lights are touched in with stopping-out varnish, the same as in etching, already described. Every successive gradation of tint is produced by this stopping-out between each biting till the deepest tints are obtained. The plate is then cleaned with spirits of turpentine and with alcohol, the resin yielding only to the latter solvent.

After a proof has been taken it may be found that some of the darks are deficient in intensity. The remedy is to pour on a new ground after making the plate perfectly clean, and the resin will granulate over the previous formation and form a re-biting ground. You now prepare a paint of yeast, molasses and whiting, or of gamboge, sugar and whiting, and with a sable brush touch in where the deeper darks are needed. Foliage relieved against a sky lighter than itself should be treated in this same manner. When this composition is quite dry, cover the whole surface of the plate with stopping-out varnish and let it dry hard. If aquafortis were now applied it could have no effect, because the entire plate is protected. Next stand the plate on an inclined position, face outward, and pour warm water over it. Fermentation begins wherever the composition has touched, and forcibly bursts away the outer varnish, and the flow of water carries it off as fast as it is liberated. The aquafortis is then applied in the manner before described, the plate cleaned, and the work is done. If edges of some of the tints are found to be too harsh and abrupt they are corrected by the use of the burnisher.

It has been found that the liquid ground granulates into a better grain on copper than on steel, and that the addition of a little sal-ammoniac improves the biting quality of the aquafortis. Great care is necessary that not the least particle of dust falls on the resin ground while in a liquid state, as it ruins it and it must be cleaned off.

Stipple engraving, a style of work done with dots in place of lines, is the same in all its methods as that already described for modern line engraving, that begins in etching, except that the graver used is slightly

curved with its point downwards, and the handle reversed so as to present the tool at a greater angle to the face of the plate. It was invented by Bylaert, of Leyden, but introduced into England from France by the unfortunate Ryland, he who executed the two whole length portraits that Robert Strange had refused. I say unfortunate, because he himself was afterward executed for the crime of forgery.

With the introduction of stippling began the publication of colored prints. The examples before you, after Stothard and Angelica Kaufman, are not colored with the brush on to the print, but are printed in oil colors from the plate itself at a single impression, the colored inks being worked into the dots of the hot plate, with the finger in the small spaces, and with the dabber in the broader ones. Among the most successful of the earlier stipple engravers was Bartolozzi (equally skillful in line, however), and you here see impressions of the etching and finished state of one of his plates in this style.

The stipple was sometimes used to imitate the strokes of a crayon drawing, as in the print before you, after a group in West's "Christ Rejected" (one of the pictures presented to the Academy by Mrs. Joseph Harrison). When in this form it was known by the term "chalk engraving." Since the discovery of crayon lithography chalk engraving has gone out of use, because the real thing is better and easier than the imitation.

Soft-ground etching has also been driven from the field by the introduction of lithography. It is the simplest and easiest of all the methods, and but few words will suffice to describe it. The example before you is by George Morland, and the fac simile of Raffaelle's study from nature for Adam in the "Temptation" is mainly by this method, but it had to be helped out afterwards with some dry point-scratching.

The ordinary etching ground has to be melted again and about one-third of its bulk of lard incorporated with it. From this it derives its name. In cold weather it requires more lard, and in warm weather less. It is spread over the plate and smoked in the same manner as hard etching ground, and then care must be observed that nothing touches it.

Take a sheet of writing paper, one inch larger every way than your plate, dampen it, and place it cautiously over your ground, turning the margin over the back of the plate, to which you fasten it with paste or otherwise; when dry, it will be stretched quite smooth. Take

an H or HB pencil, and draw your subject on it just as you wish it to appear, pressing harder where your darks are to be, and lighter for the more delicate parts. According to the weather, or as your ground is softer or harder, you select the pencil, remembering that the softer the ground the softer should be the pencil. When the drawing is finished, lift the paper carefully from the plate, and wherever you have touched with the pencil the ground will have adhered to the paper, leaving the metal plate more or less exposed. A wall of wax is then put around the subject, and the biting with aquafortis proceeded with as in other etching. If all things have gone right, a proof from the plate should resemble exactly the pencil drawing on paper, by the soft etching ground sticking to the under side of the paper.

Engraving on stone (called lithography) is not done with a graver, but with a steel or a diamond point. A smoothly polished stone is covered with a thin coating of gum water and lampblack, and the lines are drawn through this with the point, broader points being used when lines are wanted broader, not by pressing deeper into the stone. Thus the etched lines show white in the surrounding blackness, just as an etcher on metal plates is enabled to see his work by means of the smoked etching ground. The work being done, the lines are filled with greasy ink, and when the printer has cleaned off the gum and black the work appears as black lines on the white stone. After having submitted the work to the process of fixing, it is ready to print. There is quite a variety of lithographic processes practiced, but they are outside the boundary of my subject, even if there were time to touch on them.

I must now conclude, regretting that there is not time in a single discourse to taker a broader survey of this interesting subject. I have crowded into it as much as I dared, and no doubt have fatigued you all.

Cheap Dyes.—Hugo Söderström calls attention to the importance of using cheaper dyes in place of some of the exotic products, such as the yellow wood of Cuba, fustic and quercitron. He mentions especially dyers' weed, saw-wort, broom, the wood of the mulberry and acacia trees, dried pear leaves, oak bark, the bark and young shoots of the poplar, sorrel roots, the leaves of the great nettle, and juniper berries, giving rules for their successful employment.—*Wollengewerbe.* C.

ON D'AURIA'S ENGINE GOVERNOR AND THE ACTION OF GOVERNORS IN GENERAL.

By the Inventor, L. D'AURIA,

Professor of Applied Mechanics, former Engineer of the Military Topographic Institution in Italy, etc.

In March, 1879, the writer of this note submitted to the Committee on Science and Arts of the Franklin Institute of the State of Pennsylvania an improved engine governor of his own invention, called "D'Auria's Engine Governor," which was examined on model and drawing, and found to be "very simple and compact, cheap in construction, comparatively small in dimensions, extremely sensitive, quick in action, nearly frictionless and isochronous." It was constructed upon the theory set forth by the inventor in the FRANKLIN INSTITUTE JOURNAL of March, 1879. After this examination the committee expressed the desire to make a practical test of the governor, and a 1-inch D'Auria's Engine Governor, furnished by the inventor, was attached on the engine of the Franklin Institute.

This governor, except the case when the engine was run without load, was found to act practically in accordance with the previous views of the committee. It commanded three different speeds to the engine, by means of three different sets of pulleys, and these speeds were 78, 62, 48 revolutions per minute when the engine was employed in running the dynamo-electric machine, and 76, 62, 48 revolutions per minute when the engine was running said machine together with an additional resistance procured by a brake lever. When the engine was run without load, the leakage of steam through the governor valve (which was a kind of oscillating slide valve, adjusted rather loosely to prevent friction) caused the engine to run at a greater speed than that due to the sensitiveness of the governor. Considering the engine was run at a very low speed, this inconvenience was of little importance, and even this source of objection has been successfully eliminated by the inventor, by using a balanced poppet valve as a substitute for the balanced slide valve. This improvement is shown, together with some little change of form of the governor itself, in Fig. 1, in which the balanced poppet valve (shown apart in Fig. 2)

is horizontally disposed within a valve chamber, *E*, made in the governor spindle, *K*, at the end of a cylindrical tube, *T*, which tube forms a practically tight steam joint with a steam box, *B*, provided with an induction passage, *I*.

The governor spindle, *K*, projects from the steam box, *B*, through a stuffing box, and receives rotary motion from the engine by means of gear, etc.

The steam box, *B*, is provided with a flange, and covers a larger steam chamber, *S*. An eduction passage, *D*, leads from the steam box to the engine, in which steam chamber the valve chamber, *E*, and its valve revolves.

The governor arm, which is formed by two equal side pieces, *AA*, riveted on each side of a ball, revolves also in the same steam chamber, *S*, being hung on both sides of the valve chamber, *E*.

The position of the point of suspension and that of the centre of gravity of the governor arm in reference to the axis of rotation, in order to obtain the closest approximation to isochronism, are determined after the theory set forth in the FRANKLIN INSTITUTE JOURNAL of March, 1879, page 130.

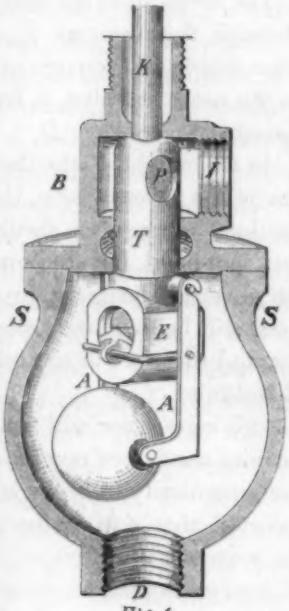


Fig. 1.

Fig. 2

The connection between the governor arm and the throttle valve is made by a wire bent in form of U, as shown on the drawing, the sides of which are confined between the sides of the governor arm and the walls of the valve chamber, so that it cannot come out unless the governor arm be taken apart from the valve chamber to allow the wire to spring.

When the governor arm swings upwards by the centrifugal force acquired through the act of revolution, the valve is carried towards its seats.

The valve moves on three wing guides, which are constructed so as to permit it to oscillate with extremely small resistance; moreover, the valve does not enter the seats, but rests only upon the

edges, thus forming the limit of motion and controlling the range of the governor arm in swinging upwards. The contrary motion of both valve and governor arm is stopped by the contact between the cross-bar of the connecting wire with the valve chamber.

The steam from the boiler enters the induction passage, *I*, and flows through the openings, *P*, of tube *T*, to reach the valve chamber, *E*, after which, if the ports of the latter are opened, it will be delivered in the steam chamber, *S*, from which it will flow to the engine through the eduction passage, *D*.

As the weight of the throttle valve is very small, as compared with that of the governor arm, the frictional resistance is easily overcome by the least increase or diminution of centrifugal force of the governor arm, produced by any small variation of speed of the engine; and the governor being isochronous, the effect of such small variations of speed will be to entirely shut or open the valve chamber of the governor, and therefore to compel the engine speed to oscillate between very close limits.

Such a governor will not only control the speed of an engine to a definite number of revolutions per minute, but it is also able to control the irregularity of a single revolution of an engine, when it must be observed that during the period of expansion of steam the action of the governor is ineffective. If at such period of the stroke an increase of load takes place, it must be controlled by the momentum either of a flywheel or of parts of machines which derive their motion from the engine; and if the speed passes, in either direction, the limits due to the sensitiveness of the governor and its control of the valve during the period of expansion of steam for each stroke, such effect can only be attributed to a deficiency of such momentum.

A great momentum in an engine is always beneficial to the action of the governor, its operation being to lengthen the time in which a change of speed takes place; but it does not in any way affect the sensitiveness of the governor. In other words, it may reduce the acceleration and retardation of speed, but it will not prevent the engine from reaching the extreme limit of its speed due to the sensitiveness of the governor.

It can be asserted that an isochronous governor, when practically frictionless, has a complete control of a steam engine. On the other hand, with a governor subjected to a considerable friction, a better

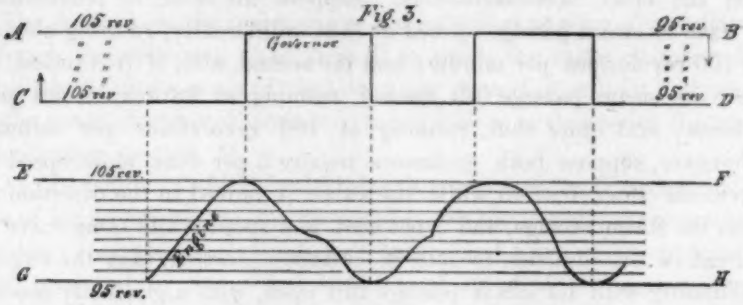
control is obtained when the isochronous properties are avoided. These propositions can be demonstrated as follows:

Imagine two governors, both subjected to friction, one isochronous and the other non-isochronous. Suppose the first, if frictionless, to have its steam passage opened or shut indifferently, running always at 100 revolutions per minute; and the second, also, if frictionless, to have its steam passage full opened, running at 98 revolutions per minute; and quite shut, running at 102 revolutions per minute. Moreover, suppose both governors require 5 per cent. more speed to overcome their friction while the valve is moved in the direction to shut the steam passage, and 5 per cent. less speed while same valve is moved in the direction to open it. Suppose, further, that the engine is running with its steam passage full open, with a gradually accelerating velocity of rotation. As soon as the speed of the isochronous governor reaches 105 revolutions per minute the steam passage will be suddenly closed by the governor valve; the speed of the engine will be now retarded, with more or less rapidity of retardation as affected by the momentum of the flywheel or moving parts, until 100 revolutions per minute is reached. At this rate of speed the governor, by our supposition, does not offer to move the valve in the direction of opening, but the operation of retardation must progress, by absorption of force from the momentum of the moving parts, until the speed falls to 95 revolutions per minute, when the valve will be full opened by the governor with the same suddenness of action. With such a governor the engine speed will be established at velocities oscillating between 95 and 105 revolutions per minute. Then if a change of load brings the engine speed to one of these limits, the governor will undoubtedly change the speed to the other limit. A graphical representation of this is given in Fig. 3, in which the distance between AB and CD represents the stroke of the governor valve. AB corresponds to the position of the governor valve when it shuts the steam passage, and CD corresponds to the position of this valve when it opens the steam passage entirely. EF and GH represent the limits of the engine speed in revolutions per minute. Between AB and CD is the line representing the action of the governor valve, and between EF and GH is the line representing the speed of the engine, with variations which correspond graphically to the action of the governor valve.

Between A and C are marked, in revolutions per minute, the positions of equilibrium of the governor while the valve moves to shut

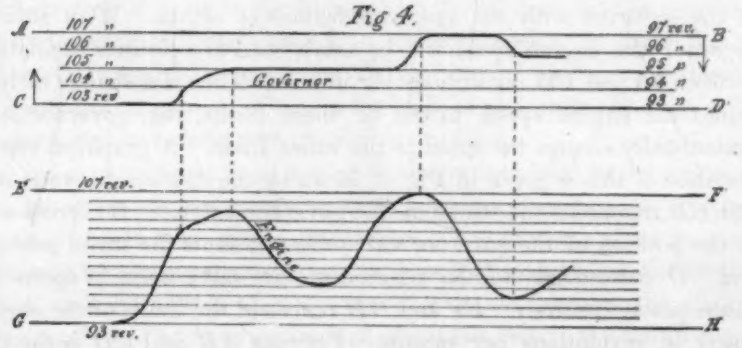
the steam passage, and between B and D are marked, in the same manner, the positions of equilibrium of the governor while the valve moves to open the steam passage.

Fig. 3.



Examining now the non-isochronous governor, with a similar supposition of open steam passage and with the speed accelerating above 102 revolutions per minute, the valve will begin to close the steam passage, and it will gradually be reduced by the valve while the speed passes from 102 to 107 revolutions per minute. When the latter speed is reached, the steam passage will be quite shut, and it will not begin to open until the speed falls to 97 revolutions per minute, because the valve would keep the steam passage closed with the governor, if frictionless, running at 102 revolutions per minute; therefore,

Fig 4.

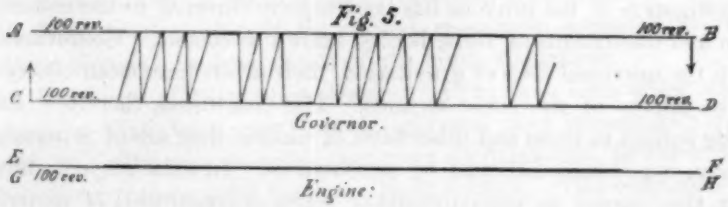


to overcome the friction while the valve moves in the direction to open the valve chamber, according to our supposition, the speed must fall to 97 revolutions per minute. While the speed passes from 97 to 93 revolutions per minute the steam passage will be opened gradually.

With such a governor the engine speed *can* oscillate between 93 and

107 revolutions per minute; but if a change of load brings the engine speed to one of these limits, then the valve will gradually open or shut the passage of steam; and it may be asserted that before the passage shall be either opened or shut, the engine will have been regulated in speed, and the uniformity of speed may be maintained with a *partly* open steam passage until another change of load may disturb it. This makes a non-isochronous governor preferable to an isochronous one, when both are subjected to frictional resistance to be overcome by the governor itself.

Fig. 5.



A graphical representation of the action of the supposed non-isochronous governor at various rates of speeds for the engine is given in Fig. 4, with the same letters of reference as in Fig. 3, referring to the similar things.

A graphical representation of the action of an isochronous and frictionless governor, and that of the engine speed, is given in Fig. 5, also with the same letters of reference as in Fig. 3, referring to similar things. In this last representation the engine speed is shown by a straight line—a condition which follows, because an isochronous and frictionless governor commands an engine to run with uniform speed.

Supernumerary Rainbows.—When a rainbow is very brilliant, secondary or supplementary bows are often seen near the centre of the arch. Kaemtz, Langwith and other observers have supposed that the reduplication is never visible near the extremities of the bow. Montigny saw, in August last, two ordinary bows with four supernumerary arches near the ground, which extended to about a third the height of the inner bow. There were two distinct layers of rain-clouds, and the supplementary bows seemed to be formed in the lower layer.—*Bull. de l'Acad. de Belg.* C.

A NEW HYPOTHESIS REGARDING COMETS AND TEMPORARY STARS.

By Thomas William Tobin,
Professor of Physics, Central University, Richmond, Ky.

Every new achievement of mechanical science to aid vision in the investigation of the heavens has been eagerly directed to the constitution and movements of those bodies known as comets. Conformably with the universal laws of gravitation, their orbits have been observed to be curves of the conic sections. The conclusion, therefore, that being subject to these and other laws of matter, they are of a material nature, is generally believed by astronomers. In some respects, however, they appear as embodiments of force, or constituted of material of such an attenuated form as to have, as far as we know now, no terrestrial equivalent.

Those having parabolic and hyperbolic orbits are doubtless visitants from other systems than ours, returning in new paths to again encounter other systems. We may regard them as the true planets of the siderial heavens, so erratic must be their paths in space.

There is another class of siderial phenomena to which the merest hypotheses can be applied, and even then with but little satisfaction to the mind of the investigator. It has afforded a field for the wildest flights of imagination in darker ages of astronomy, and frail romance has interwoven it with immediate divine interposition. It is the sudden appearance and equally sudden disappearance of stars in the heavens.

Of this class we may take, as a notable and historical example, the temporary star of 1572, which was observed and recorded by the celebrated Tycho Brahe. "Suddenly," says the record, "there appeared in the constellation of Cassiopeia a star that in brightness surpassed Sirius, and it could be compared with Venus when she is at her brightest. It was seen in the day time, and at night through clouds of considerable density. Its position was carefully noted, to make sure it was not a comet. In December its brightness began to diminish, and it gradually passed through degrees of brightness until February, 1574, when it vanished, having been visible 17 months. Its color was first

white, then yellow, and finally red. Some astronomers imagined that it would reappear again after 150 years, but it has never been discovered since. It alarmed the astronomers of the age who beheld it, and many of them wrote dissertations concerning it."

Amongst numerous other temporary stars that have from time to time appeared, the following may be quoted.

In 1604 a star appeared in Serpentarius and remained visible 15 months, then disappeared.

In 1848, in Ophiuchus, a star of the fourth magnitude appeared; in a few weeks it diminished to a star of the twelfth magnitude.

In May, 1866, a star of the second magnitude appeared in the northern crown. In June it was of the ninth magnitude.

La Place says of these phenomena: "As to those stars which suddenly shine forth with a very vivid light and then immediately disappear, it is extremely probable that great conflagrations, produced by extraordinary causes, take place on their surface. This conjecture is confirmed by their change of color, which is analogous to that presented to us on the earth by those bodies which are set on fire and then gradually extinguished." Mrs. Somerville says, "It is impossible to imagine anything more tremendous than a conflagration that could be visible at such a distance."

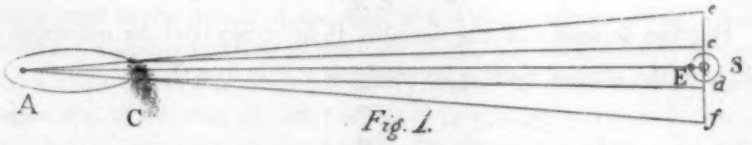


Fig. 1.

Presuming that in the course of time all possible relations in the positions of the heavenly bodies to each other must take place, we may assume that between a far distant and to us invisible sun, a comet may make a transit in such a position as to be directly in a line with the earth. Under such circumstances we will now consider the possible phenomena that would occur.

In Fig. 1, *A* represents such distant star, *S* our solar system, *E* the earth, and *C* a comet in the aphelion of its orbit about the star *A*.

Now if the nucleus and coma of the comet have density and transparency, both of which are probable, the rays of light emanating from the distant star *A* would suffer refraction, and the area represented by the line *e f*, which would be filled by the obstructing space of the comet,

thus reduced in amount and inversely increased in intensity to the space $c\ d$, the ratio of $e\ f$ to $c\ d$ being dependent upon the refractive and dispersive power of the cometary mass.

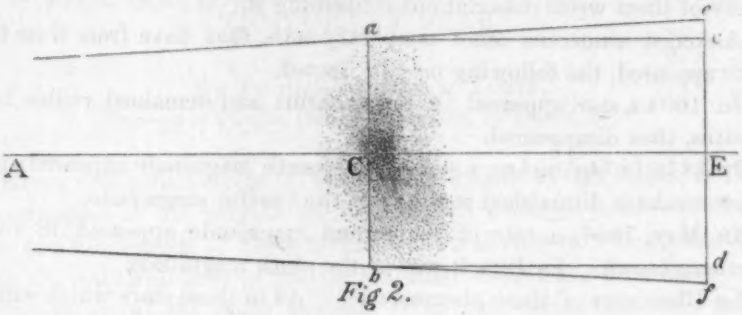


Fig 2.

Let us take Fig. 2 as an enlarged representation of the comet, in which A produced is the distant star and E the position of the earth. The amount of the normal rays that would be encountered by C may be represented by $\overline{a\ b}^2$ and at the earth by $\overline{e\ f}^2$, which by refraction will be represented by $\overline{c\ d}^2$. Call these respectively a^2, e^2 and c^2, and we may then have the proportion

$$\frac{a^2}{e^2} = \frac{\overline{C\ A}^2}{\overline{E\ A}^2} \qquad (1)$$

But the intensity of the variable light v, received by refraction at E, is to the normal light n inversely as $\overline{c\ d}^2$ is to $\overline{e\ f}^2$, or

$$\frac{e^2}{c^2} = \frac{v}{n} \qquad (2)$$

$$\therefore v = \frac{n\ e^2}{c^2}$$

Substituting the value of e in (1) we get

$$v = \frac{n\ a^2\ \overline{E\ A}^2}{c^2\ \overline{C\ A}^2} \qquad (3)$$

In the event of refraction producing parallel rays from C to E, then $\overline{c\ d}$ being equal to $\overline{a\ b}$, or $c = a$, we have

$$v = \frac{n\ \overline{E\ A}^2}{\overline{C\ A}^2} \qquad (4)$$

Now the star α, Centauri, the nearest to our sun, is in round num-

bers 21 millions of millions of miles distant from it. Taking, as an illustration of the foregoing, the approximate magnitude and distance of a comet similar to that which passed through our system in 1680 as

Aphelion, . .	13,000,000,000 miles.
Perihelion, . .	130,000 "
Velocity at perihelion, .	1,000,000 miles per hour.

According to (4), if such a comet should pass between that star and us under the foregoing conditions, $x = 2{,}600{,}000$, or it would increase two and a half million times the brightness of that star!

The relative brightness of a star of the first magnitude compared with one of the sixth magnitude, according to Herschel, is as 100 to 1. We may therefore form some conception what values in the equations (3) and (4) would bring a star from the sixth magnitude, or even from obscurity, to the first magnitude of brightness. But we are presuming on a dispersive power of the coma greater than it probably possesses. The usual cometary form of the nucleus and coma, if retained at that distance from its sun, would itself be conducive to a high dispersive power, and should the tail be retarded in its orbitual progress, causing the denser portion to be in advance of the centre of the comet, the sudden appearance of white light and its passage through the less refrangible rays, yellow and red, before extinction, would account for the phenomenon of a "burning out," as already described.

In regard to the period of duration of the phenomenon. In aphelion this comet would, according to the data given, possess a velocity of not greater than about ten miles per hour; and if its diameter were one-quarter that of the star, the time occupied in making a transit is easily reconciled, at least with the times of those variations of 1848 and 1866, and can easily be conceived to occupy a few weeks in duration.

Of course these illustrations are, for lack of data of the distances and actual magnitude of the fixed stars and comets, merely speculative attempts to reconcile the variations of the temporary stars with the transit of cometary masses, if at all reconcilable. We cannot conceive the vastness of the mechanism of this universe, which must ever exist in our imagination with the mere term infinite applied to it. As a speculation it appears more rational than the romance of the sudden destruction of entire systems by means of equally sudden and inconceivable conflagrations.

Although outside the bounds of pure science, speculative philosophy has often been the means of directing the course of investigation of

truth. In the nature of such only has the foregoing been set forth. If some future observations on comets, specially directed to their materiality of composition, confirm the present notion, that they have density and transparency, that light in passing through their media suffers no refraction, then we must look for a new form, may be a fourth state of matter, in their constitution.

PRACTICAL ITEMS AND RECIPES.

By R. Grimshaw.

[These are in every case drawn from the compiler's personal experience, or obtained by him at first hand from those who have tested and approved them.]

To Conduct Ozonized Air use kerite tubing.

To Straighten Iron Wire and Light Rods.—Roll between two wide flat boards.

To Destroy Phylloxera, sprinkle the vines and saturate the soil with bisulphide of carbon.

Quick Dryer for Printers' Inks.—Use borate of manganese, which will also give a "gloss" effect.

Hardening Drills.—To give drills and other steel articles an unusual hardness, without brittleness, use mercury.

To Cut India Rubber Easily.—Keep the knife-blade wet with water, or, better still, with a strong solution of potash.

Very Porous Draining Tiles are made by mixing large quantities of sawdust with the plastic clay and burning as usual.

Springs of Tumbler Locks are best made of phosphor bronze, as preserving its toughness and elasticity and avoiding breakage or inaction.

To work Cork into symmetrical shapes, as pen handles, etc., cut approximately to shapes with a *greased* knife, using a drawing cut, and finish with a coarse emery wheel.

Hot Bearings are relieved and prevented by the use of graphite as a lubricator—either pure or well mixed in oil. This is good for the heaviest journals and highest speed.

Rubber Valves for Steam or for Oil, should be specially ordered for the purpose desired, as they require to be vulcanized at a higher temperature or for a longer time.

To Prevent Nickel-Plating from Scaling off iron or steel objects, copper them first by battery or by simple immersion in a strong solution of sulphate of copper (blue vitriol).

Clearance for Narrow Saw Blades may be given, without either spring or spread set, by grinding the back to a knife edge. This is especially useful for keyhole, pruning and fret saws.

In Buying Rubber Goods, as car-springs, buffers, etc., *choose light ones;* heavy ones are loaded up with barytes, etc. Color is no test. Never buy old India rubber goods, as that material "perishes" with age.

The Heating of Hot Link Blocks is very common in steam fire engines of the Amoskeag and similar patterns. It may be avoided by substituting for the composition generally used lignum-vitæ or apple-wood blocks.

File Handles, to firmly hold double-ended or reversible saw-files, may be made by boring half-way down with a large bit, and deeply with a smaller one, thus giving the triangular file section a bearing at two places in its length.

To Grind Vermilions without Browning them, use a mill having two rollers of diameters three to one, and the same number of revolutions per minute. They have a "slip motion," or true mulling action, and as there is only a line of contact, instead of a great surface, such mills grind cool and do not turn the color.

"False Back" Union or Hose Couplings are easily made, so true as to be nearly water tight without washers at ordinary pressures, by casting the male first with a square encircling groove, which, after being trued in the lathe and coated with charcoal blackwash, or with graphite, has the female portion cast around it.

To "Bring up" a Short Circular Saw Tooth.—Sometimes one tooth strikes a knot, stone or spike, and loses only the tip end. Instead of filing the whole saw down to agree with the short tooth swage it with a crotched steel tool, gently lifting the tool as the hammer strikes it. This will raise the end, and bring the tooth into line.

To Preserve Leather Hose, Belting, etc., in good condition, freely apply crude castor oil, warmed if possible. It increases the pliability of the leather and the cling of belts; does not become rancid. Rats avoid it. In hose, it should be pumped in from the interior under considerable pressure, thus thoroughly filling the pores.

Cheap Suction Hose for wrecking purposes, bridge caissons, etc.,

may be made by sewing cotton duck into a tube of the desired diameter and springing into it a coil of stout galvanized iron wire, wound on a wooden or other mandrel, a trifle larger than the hose. The ends of the coil must be secured to the couplings. A coat of boiled linseed oil renders it water-tight.

Gates or Locks for Pneumatic Tubing are best made, instead of with complicated valve chambers, ecc., by simply surrounding the terminus with a snug-fitting sleeve which has about 175° of its circumference removed throughout most of its length, to correspond with a similar opening in the tube. Semi-rotation, or lengthwise sliding, of the sleeve opens full or tightly closes the tube end.

Copying Ink, to be made without Press or Water.—Well mix about three pints of jet-black writing ink and one pint of glycerine. This, if used on glazed paper will not dry for hours, and will yield one or two fair neat dry copies, by simple pressure of the hand, in any good letter copy book. The writing should not be excessively fine, nor the strokes uneven or heavy. To prevent "setting off," the leaves after copying should be removed by blotting paper. The copies and the originals are neater than where water is used.

Drawing on Photographs.—Where it is desired to obtain an India ink drawing from a photograph, without resorting to tracing, very nice results are obtained thus: Prepare a print in the usual manner. Instead of toning as usual, fix immediately in "hypo." Wash well in running water to get out all the hypo. Draw directly on the print with India ink. This finished, bleach with a saturated solution of corrosive sublimate (bichloride of mercury) in equal parts of water and alcohol. Flowing is better than brushing, for applying the bleach, as it avoids smearing.

Keeping Wet Plates from Drying.—As dry plates are not always obtainable, and ordinary wet plates dry so quickly as not to allow transporting, it often becomes necessary, in order to make a single picture, to carry as much apparatus as would be required to make a dozen or more. A very good method of preparing a wet plate so as to last for several hours consists in flowing the plate (after taking out of the bath) with a mixture of one part of strong solution of silver (eighty grains to an ounce) and two parts chemically pure glycerine. Flow and drain the plate until all streaks disappear and the plate remains smooth. This dispenses with carrying the bath and useless chemicals. The plate may be developed on returning home.

Bone Glass.—After extracting phosphorus from bones, a glass can be formed from the residue, which consists of lime and phosphoric acid; the ordinary kinds of glass being composed of sand and potash, soda, lime and alumina. Bone glass can be worked as readily as any other glass. It has the valuable property of not being attacked by fluoric acid.—*Les Mondes.* C.

Petroleum in France and Italy.—A Franco-Italian company has been formed to explore Southern Europe for petroleum. Experts, with boring apparatus, have been brought from the United States, and the local authorities have promised liberal aid to the undertaking. The first wells are to be sunk at Tocco, in the Abruzzes, and at Rivanazzano, in Lombardy.—*Chron. Industr.* C.

Phoneidoscope.—M. Guebhard describes a method of projecting the colored rings which are produced on the surface of mercury by the breath or by a drop of volatile liquid. He also obtains membranous rings by substituting a drop of collodion or of varnish for the volatile liquid. These rings may be fixed upon a card and preserved indefinitely. Phoneidoscope figures may be obtained by pronouncing different sounds so that the breath may be intercepted by the mercurial surface.—*Soc. Franc. de Phys.*

Economical Fngineering in the St. Gotthard Tunnel.—Colladon enumerates the following advantages from the use of his compressors: 1. A saving of more than 600,000 francs ($120,000) in the simple purchase of compressors. 2. The reduction of the cost of buildings to about one-tenth of what would otherwise be required. 3. A ventilation so complete that the ventilating fans, which had been previously purchased, are entirely useless, and their whole cost might have been avoided.—*Mem. de la Soc. des Ing. Civils.* C.

Detection of Starch in Milk.—The adulteration of milk by starch can be readily detected by the following method. Add a few drops of acetic acid to a small quantity of the suspected milk; boil the milk, and after is has cooled filter the whey. If there is any starch in the milk, a single drop of iodine solution will give a blue tint to the whey. This process is so delicate that it will show the presence of a milligram of starch in a cubic centimetre of whey (1 grain of starch in 2·16 fluid-ounces of whey).—*La Gaceta Industrial.* C.

Packing for Steam Pipes.—J. Kathe makes a packing which also may be used as a non-conductor, for wrapping the pipes, by grinding 20 parts of hemp-refuse and mixing it in a Hollander with 40 parts asbestos, 20 parts wool-waste and 20 parts wood-pulp. The mass is then saturated with soluble glass and dried.—*Dingler's Journal.* C.

Prediction of Earthquakes.—J. Delauney has found, by examining the tables of earthquakes from 1705 to 1842, four groups of maximum frequency which occur when Jupiter and Saturn are at the mean longitudes of 265° and 135°. He therefore predicts an unusual number of earthquakes in the years 1886, 1891, 1898, 1900, 1912, 1919, 1927 and 1930.—*Comptes Rendus.* C.

Chlorophyll.—In 1877 Gautier prepared crystals of pure chlorophyll, and he has been studying its properties and affinities. A recent paper of Hoppe-Seyler has induced Gautier to announce his method of removing the impurities which vitiate most of the published observations. He finds numerous interesting resemblances to bilirubine and hematine, and anticipates, from further researches, results of great importance for vegetable physiology.—*Comptes Rendus.* C.

New Thames Tunnel.—A tunnel has been authorized by Act of Parliament between Greenwich and Millwall, two districts which have an aggregate population of 259,000 persons. When the ferry-boats are interrupted by the frequent fogs, a detour of about twelve miles has to be made in order to cross by way of London bridge. The new sub-way, which will be the fourth tunnel beneath the Thames, will be a third of a mile long, approached by a descent of fifteen steps at Millwall and by twenty-four steps at Greenwich.—*L'Ingen. Univ.* C.

Safety of Dynamite Cartridges.—Louis Roux says that the transport of dynamite should be entirely prohibited except when divided into small cartridges. When such cartridges are surrounded by some material, such as sand or sawdust, which absorbs any escaping liquid, perfect security may be obtained. In spite of the large quantity of dynamite manufactured during the last few years, not a single accident has occurred from transportation or storage. A box of dynamite cartridges may be let fall from a height great enough to break it, or crushed by the fall of heavy weights, or placed between the buffers of colliding railroad cars, without producing an explosion.—*Ann. du Gen. Civ.* C.

Electric Phenomenon.—E. Lamaire observed the following phenomenon during a snow-storm: The wind was blowing from E.S.E., the sky being very cloudy and the thermometer standing at 1° below zero (30·2°F.). At the beginning of a violent squall of snow little luminous points appeared at the extremity of each of the iron ribs of his umbrella, accompanied by a rustling similar to the buzzing of an insect. When he approached his ungloved hand to one of these points he felt a slight shock in the first two fingers, and the light disappeared. The experiment was repeated many times, and the phenomenon lasted four or five minutes, until the umbrella was covered with a thin coat of snow.—*Comptes Rendus.* C.

Proposed Circular Canal at Milan.—Perhaps no city of Italy has become more greatly benefitted by national independence than Milan. Among the schemes of public improvement which are attracting attention is the proposal of Francesco Ajraghi for a canal around the city. The estimated expense is 10,087,766 lire ($2,017,553.00). Among the proposed advantages are: 1. Increased facilities for the distribution and storage of commercial products. 2. Completion and extension of the system of irrigation. 3. A motive force of 6281 horse power, available for manufacturing. 4. Increased revenues from local imports of various kinds, from rents and from the sale of city lands. 5. A better and more abundant supply of excellent water for household use and for ornamental fountains. 6. Improved sanitary conditions, expecially in the suburbs.—*Il Politecnico.* C.

Calorific Effect of Steam Boilers.—Scheurer-Kestner estimates the loss of heat from the fire of a steam boiler, by radiation and conduction, at 25·5 per cent. Some writers say 40 per cent. As the loss has never been directly determined, but only estimated from the differences between other data which were imperfectly ascertained, these figures are very problematical. Ferdinand Fischer suggests experiments with combustibles of uniform composition, such as illuminating gas or petroleum, for determining calorific values and the various losses of heat. By adding the quantity of gas set free by combustion and elevated temperature, and taking account, by the help of Linde's formulas, of the specific heat which varies with the temperature, it would be possible to reach an accurate knowledge of the amount of heat trasmitted through the metal to the water of the boiler.—*Dingler's Journal.* C.

Franklin Institute.

HALL OF THE INSTITUTE, March 17th, 1880.

The stated meeting was called to order at 8 o'clock P.M., the President, Mr. William P. Tatham in the chair.

There were present 128 members and 44 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that 21 persons were elected members of the Institute at their last meeting.

The following donations to the Library are reported by the Secretary:

Report upon Forestry. By F. B. Hough. Washington, 1878.
From the Author.

Report of a Board of United States Naval Engineers on the Herreshoff Boiler.
From the Bureau of Steam Engineering, N. D., Washington, 1879.

Scientific Writings of James Smithson. Edited by W. J. Rhees. Washington, 1879.

Smithsonian Institution: Journals of the Board of Regents, Reports of Committees, etc. etc. Edited by W. J. Rhees. Washington, 1879.
From the Editor.

Germanischer Lloyd. Internationales Register, 1880.
From L. Westergaard & Co., Philadelphia.

Railroad Engineers' Practice, By Thos. M. Cleeman. New York, 1880. From the Author.

Catalogue of Chambers Bros. & Co. Folding Machines, etc.
From C. Chambers, Jr.

Geographical Explorations and Surveys West of 100th Meridian. Topographical Atlas, 1875. From the Dept. of the Interior.

Charter and By-laws, Report and Proceedings of the Numismatic and Antiquarian Society of Philadelphia. 1865 to 1879.
From the Society.

Fourth Annual Report of the Board of Trustees of the Pennsylvania Museum and School of Industrial Art. 1879.
From the Museum.

Methods and Results Standards of Measure of the United States compared with those of Great Britain and France. Washington, 1879. From the U. S. C. and G. Survey.

Catalogue of the Library of the United States Naval Observatory. Washington. Part 1. Astronomy, Bibliography. By Prof. E. S. Holden. 1879. From the Observatory.

Report on the Meteorology of Kerguelen Island. By S. J. Perry. London, 1879. From the Royal Society.

Annals of the Astronomical Observatory of Harvard College. Vol. 11. Part 2. From the College.

Resultados del Observatorio Nacional Argentino en Cordoba. B. A. Gould, Director. Vol. 1, 1879, and Atlas.
From the Observatory.

Annual Report of the Light-house Board to the Secretary of the Treasury for the year ending June 30, 1879.
From the Light-house Board.

Annual Report of Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the year ended June 30, 1877, and Part 1 of Foreign Commerce, 1878.

Annual Statements of the Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the fiscal year ended June 30, 1878. Part 2. Foreign Commerce.

Annual Statements of the Chief of the Bureau of Statistics on the Commerce and Navigation of the United States for the fiscal year ended June 30, 1879. Foreign Commerce.
From the Treasury Department, Washington.

United States Entomological Commission. Bulletin No. 3. The Cotton Worm. By Charles V. Riley.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. 5. No. 3. Washington.
From the Interior Department.

Report of the Meteorological Council to the Royal Society for the year ending 31st of March, 1879. London. From the Society.

Tenth Annual Report of the Board of Directors of City Trusts for 1879. From the Board.

The Duty on Steel Rails. The Case for the Manufacturers, at a Hearing before the Ways and Means Committee of the House of Representatives. Washington.

Memoir of Henry C. Carey. By William Elder.
From the American Iron and Steel Association.

Inter-Oceanic Canal Projects. Discussion before the American Society of Civil Engineers. From the Society.

Publications of the Cincinnati Observatory. No. 5.
Micrometrical Measurements of Double Stars. 1878 to 1879.
From the Observatory.

Official Army Register for January, 1880.
From the Adjutant-General's Office.

Joint Committee of the Councils of the City of Philadelphia on Commerce and Navigation, etc., etc. From Council.

Annual Report of the Commissioner of Agriculture for 1878.
From William G. Le Duc, Commissioner.

Historical Sketch of Henry's Contribution to the Electro-magnetic Telegraph. By William B. Taylor. Washington.
From the Author.

Annual Report of the Chief of the Bureau of Steam Engineering for 1879. Washington. From the Bureau.

Circulars of Information of the Bureau of Education. No. 5. 1879. Washington. From the Bureau.

Zweite Abhandlung über die Wasserabnahme in den Quellen, Flüssen und Strömen, etc. Von Gustav R. Von Wex. Wien, 1879.
From the Ostereich. Ingen. u. Architekten Verein.

United States Northern Boundary Commission. Declinations of Fixed Stars. By Lewis Ross. From the Dudley Observatory.

Report on the Madras Cyclone of May, 1877. By J. Elliott. Calcutta, 1879.

Report on the Administration of the Meteorological Department of the Government of India in 1877–78.

Report on the Meteorology of India in 1877. By John Elliot.
From the Meteorological Dep't Gov't of India.

Zur Kentniss der Fauna des Untersten Lias in den Nordalpen. Von Dr. M. Neumayer. From the K. K. Geolog. Reich't.

Catalogues, Circulars and Reports of the Pennsylvania State College of Agriculture. 1862 to 1879. From the College.

Mr. Louis H. Spellier read the paper announced for the evening, on "Electric Time Telegraphs."

The Secretary read the report of Prof. Henry Morton on the Tests made of the Electric Light at the Coney Island Pier in September last.

It was stated, in explanation of the purpose of this examination, that the Brush Company had agreed to give light of 2000 candle power, each with 22 horse-power, the small machine to run 900 revolutions per minute, the large one 750 revolutions per minute. They exceeded this speed four per cent. The twelve inch carbons used cost fifteen cents each, and the consumption was two inches per hour each.

Mr. McKean inquired what equivalent light in gas jets per horse-power was furnished, saying that so many "candles" was not as clear an expression as to volume of light as so many gas jets, with the power of which we are familiar.

At the request of the President, Prof. Rogers explained the manner of testing lights by comparison with standard candles, and mentioned a new means of testing lights for their color by establishing a standard of incandescent platinum heated by a battery of known power.

Mr. McKean expressed his thanks for the information as to candle power, but again repeated his question.

The President stated that it was only a matter of calculation. The average power of the lights was said to be 500 candles. There were 16 lights, giving an aggregate of 80,000 candles, by the expenditure of 21½ horse-power, or nearly 400 candles per horse-power. From this the number of gas jets of given candle power could be calculated. He called attention to the fact that, while the large machine mentioned in Prof. Morton's letter required 1·35 horse-power per light, the smaller machine, running six lights for 4·3 horse-power, required only about ·71 horse-power per light.

Prof. Marks said that at Wannamaker's Depot there were 50 lights maintained by 65 horse-power, more than a horse-power for each light, and almost exactly the same as the results shown by the larger machine mentioned in Prof. Morton's letter. He said that at Edison's the light of only about 25 or 30 candles, he believed, was obtained per horse-power.

Prof. Rogers said that there was no doubt of the fact that the economy of power was enormously greater in the voltaic arc system than in the incandescent system of electric lighting. His estimate of the amount of light furnished at Edison's laboratory was a little higher than that of Prof. Marks—about 40 candles per horse-power—while that of the lamps mentioned in Prof. Morton's letter was 400 candles per horse-power, a difference of ten to one in favor of the voltaic arc. Economy cannot be obtained by the incandescent method.

Mr. Robert Briggs, taking as his text a paper on L. D'Auria's governor, published in another part of the JOURNAL, described the manner in which it operated, and repeated and endorsed the statements in the paper as to the governor being practically frictionless and isochronous.

Prof. William D. Marks, of the University of Pennsylvania, in describing a governor of his invention, said that it was possible to proportion the reciprocating parts of an engine so as to get very little variation on the crank pin. The next agent employed to secure steadiness is the fly-wheel, which will prevent a change of more than a certain amount during a stroke. Then the engine will go on gaining in speed, unless we employ a governor to prevent that. He did not believe there was such a thing as an absolutely isochronous governor. The cut-off governor so regulates the valve and cuts off steam in the cylinder that, whatever the variations of pressure and load may be (within limits), the engine will run at an approximately uniform speed. The throttling governor is the commonest form in use. With it there is a different velocity of governor with every change of pressure or of load. With every change of speed there is a different position of the governor ball and a different position of the valve. The governor changes constantly, always running a little faster or a little slower than the mean. It is constantly vibrating on either side of the mean, and this must be true as long as the laws of centrifugal force exist. The weight of the balls is constant, but as they spread outward the governor becomes less and less sensitive.

In my governor the pendulum spindle is in two sections. The lower one is capable of sliding lengthwise a little at the same time that it turns the upper one and screws up and down in the hub of its driving wheel. It is connected to the wheel by a spring, which operates to make the wheel overrun the spindle or the spindle overrun the wheel, according to whether the speed of the engine is increased or slackened. By this means the valve is closed or opened in advance of any change of speed in the pendulum. The sensitiveness of the governor depends upon the flexibility of the spring, its power to move the valve upon the pitch of the screws. The inertia of the governor balls is utilized to move the valve in advance of any change in the governor's speed, the inertia of the balls tending to close the valve when the engine attempts to increase its speed and the momentum of the balls opening the steam valve when the speed is decreased. The governor balls maintain a uniform speed, to which the engine conforms more or less closely according to the sensitiveness of the spring. No engine governor is isochronous in the scientific sense of the word, but this governor can be made to hold the engine very close to a standard speed and with little loss of power.

Mr. Briggs said that the Marks' Governor was of a different type from the D'Auria, and possessed advantages over the ordinary throttling governor. He thought that a first class engine must have a cut-off governor.

Mr. Nystrom said that it had been intimated that an isochronous governor could not be made. The water governor is practically isochronous, and he did not see why it could not be adapted to steam engines. The resistance of the air employed in Prof. Marks' governor was an old principle and had been heretofore used.

Prof. Marks said that he held the view that a governor could not be made absolutely isochronous, because it must change its speed before it could act. This is due to the fact that the degree of opening of the steam valve is directly controlled by the angle to which the governor balls are raised, the steam valve being moved only by a change of speed resulting from a change in the angle of suspension of the balls. A higher speed is necessary to reduce the supply of steam to meet a reduction of work.

Mr. Nystrom said he admitted that, but claimed that the variation could be made so slight as to make the governor practically isochronous.

Mr. Hugo Bilgram remarked that, in engines with cut-off governors, from the time of cut off to the same period of the next stroke, the governor exercised no control, and that if during that interval of time the load was decreased the speed of the engine would be increased. Within the period of about one revolution the governor is powerless.

THE PRESIDENT.—The fly-wheel takes care of that.

MR. BILGRAM.—Yes, the fly-wheel and the governor are complementary and work together for that purpose. This closed the discussion, Prof. Marks answering queries as to his governor after the meeting, when it was shown in operation on the engine belonging to the Institute.

Mr. S. P. Burdict made a few remarks upon a large eight-day lever clock he exhibited, altered from a thirty-hour one originally made by the late Eli Terry, of Connecticut.

The Secretary's report included an account of Weaver's Metallic Envelopes for the safe transmission of articles in the mails; Hall's Health Syringe, in which nothing but air passes through the bulb and valves, which, pressing upon the liquid in the bottle, forces it out through a tube reaching to the bottom of the vessel; Butler's Electro

type Ornaments, made from gutta percha moulds, for cabinet makers' use; Coppuck's Patent Car Coupling, an ingenious device enabling the brakesman to couple and uncouple cars without endangering his hands. Short papers were also read on Watson's invention to protect the body from extreme cold; Pneumatic Clocks; Uralium and the prices of rare metals; Cementing metals to glass; Artificial production of the Diamond; St. Gothard Tunnel; Photographic Etching on Copper, and the Carpet Trade of Philadelphia. Attention was also called to a fine painting of the Library Room of the Franklin Institute, on exhibition, the work of Mr. C. C. Cooper, Jr., of Germantown.

The Secretary announced the deaths of Mr. Wm. H. Howard, one of our early members, and Mr. John Richards. An obituary notice of the latter was read from *Engineering*.

Mr. Mitchell moved that a committee be appointed to prepare suitable resolutions of regret, and report at the next meeting, which was carried.

The President named the following standing committees for the year:

On the Library.—Chas. Bullock, Lewis S. Ware, Dr. Isaac Norris, Jr., Rob't Briggs, Henry Bower, Henry Pemberton, John H. Cooper, J. E. Mitchell, Jos. M. Wilson, Fred. Graff.

On Minerals.—Dr. F. A. Genth, Theo. D. Rand, Clarence Bement, Persifor Frazer, Jr., Dr. W. H. Wahl, E. J. Houston, Otto Luthy, E. F. Moody, Dr. G. A. Kœnig, H. Pemberton, Jr.

On Models.—C. Chabot, H. L. Butler, Edward Brown, M. L. Orum, J. Gœhring, L. L. Cheney, J. J. Weaver, S. Lloyd Wiegand, A. G. Busby, N. H. Edgerton.

On Arts and Manufactures.—J. J. Weaver, George V. Cresson, Hector Orr, Coleman Sellers, Jr., W. B. Le Van, Wm. Helme, J. S. Bancroft, Alfred Mellor, Cyrus Chambers, Jr., Geo. Burnham.

On Meteorology.—Pliny E. Chase, Hector Orr, Dr. Isaac Norris, Jr., David Brooks, Jas. A. Kirkpatrick, Alex. Purves, Dr. W. H. Wahl, F. M. M. Beale, H. Carville Lewis.

On Meetings.—H. Cartwright, Washington Jones, L. M. Haupt, W. L. Dubois, W. H. Thorn, Cyrus Chambers, Jr., J. J. Weaver, Fred'k Graff, Addison B. Burk.

On motion, the Institute adjourned.

ISAAC NORRIS, M. D., *Secretary.*

RECENTLY PUBLISHED.

KITCHEN BOILER. — The Kitchen Boiler and Water Pipes. A few words on their arrangement and management; more especially their treatment during frost, and how to avoid explosions. By H. Grimshaw, F.C.S. 8vo, paper, 40 cents.

CORLISS ENGINE.—Corliss Engine and Allied Steam Motors working with and without Automa ic Variable Expansion-gear including the latest most improved Engine Designs of all Countries, with special references to the Steam Engines of the Paris International Exhibition of 1878. For Engineers, Machinists, Steam Users and Engineering Colleges. Translated from W. H. Uhland's work, by A. Tolhausen, Jr., C.E. In folio and 4to. *Ready shortly.*

SCIENCE INDEX.—The Science Index. A Monthly Guide to the Contents of Scientific Periodicals. Consisting of a Classified Alphabetical List of the titles and authors (if known) of articles of scientific or technical interest that have appeared in periodicals during the previous month. Each issue will comprise about 60 quarto pages. It will be sold only by subscription, payable in advance. Price per annum $5.00.

STEEL.—A Treatise on Steel: Its History, Manufacture and Uses. By J. S. Jeans, Sec. of the Iron and Steel Institute. In one large volume, 8vo, with numerous plates and woodcuts. *Ready shortly.*

TABLES OF SPEEDS.—Tables of the Principal Speeds occurring in Mechanical Engineering, expressed in Metres, in a Second. By P. Keerayeff. Translated by Sergius Kern, M.E. 18mo paper, 20 cents.

HEAT.—A Practical Treatise on Heat, as applied to the Useful Arts, for the use of Engineers, Architects, etc. By Thomas Box. Second Edition. Plates. 8vo, cloth, $5.00.

COAL.—A Practical Treatise on Coal Mining. By George G. André, F.G.S. Complete in two volumes, royal 4to, cloth, containing 550 pages of letter-press and 84 plates of practical drawings. Price, $28.00.

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